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A Remarkable Textbook

Barber's First Course in General Science

By FREDERICK D. BARBER, Professor of Physics in the Illinois State Normal University, MERTON L. FULLER, Lecturer on Meteorology in the Bradley Polytechnic Institute, JOHN L. PRICER, Professor of Biology in the Illinois State Normal University, and HOWARD W. ADAMS, Professor of Chemistry in the same. vii+588 pp. of text. 12mo. $1.25.

A recent notable endorsement of this book occurred in Minneapolis. A Committee on General Science, representing each High School in the city, was asked to outline a course in Science for first year High School. After making the outline they considered the textbook situation. In this regard, the Committee reports as follows:

"We feel that, in Science, a book for first year High School use should be simple in language, should begin without presupposing too much knowledge on the part of the student, should have an abundance of good pictures and plenty of material to choose from.

Barber's *First Course in General Science* seems to us to best meet these requirements and in addition it suggests materials for home experiments requiring no unusual apparatus, and requires no scientific measurements during the course. We recommend its adoption."

Other Interesting Opinions on the Book Follow:

SCHOOL SCIENCE AND MATHEMATICS:—It is one of the very best books on general science that have ever been published. The biological as well as the physical side of the subject is treated with great fairness. There is more material in the text than can be well used in one year's work on the subject. This is, however, a good fault, as it gives the instructor a wide range of subjects. The book is written in a style which will at once command not only the attention of the teacher, but that of the pupil as well. It is interesting from cover to cover. Many new and ingenious features are presented. The drawings and halftones have been selected for the purpose of illustrating points in the text, as well as for the purpose of attracting the pupil and holding his attention. There are 375 of these illustrations. There is no end to the good things which might be said concerning this volume, and the advice of the writer to any school board about to adopt a text in general science is to become thoroughly familiar with this book before making a final decision.

WALTER BARR, *Keokuk, Iowa*:—Today when I showed Barber's Science to the manager and department heads of the Mississippi River Power Co., including probably the best engineers of America possible to assemble accidentally as a group, the exclamation around the table was: "If we only could have had a book like this when we were in school." Something similar in my own mind caused me to determine to give the book to my own son altho he is in only the eighth grade.

G. M. WILSON, *Iowa State College*:—I have not been particularly favorable to the general science idea, but I am satisfied now that this was due to the kind of texts which came to my attention and the way it happened to be handled in places where I had knowledge of its teaching. I am satisfied that Professor Barber, in this volume, has the work started on the right idea. It is meant to be useful, practical material closely connected with explanation of every day affairs. It seems to me an unusual contribution along this line. It will mean, of course, that others will follow, and that we may hope to have general science work put on such a practical basis that it will win a permanent place in the schools.

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THE SCIENTIFIC MONTHLY

JULY 1919

PHYSICAL REJECTION FOR MILITARY SERVICE; SOME PROBLEMS OF RECONSTRUCTION

By J. HOWARD BEARD, M.D.

UNIVERSITY OF ILLINOIS

THE draft has been a great inventory of the resources of the nation—it has shown both our physical assets and our human liabilities. The material was found to be of good grade; but 29.11 per cent. of the registrants were rejected by the physicians of the local boards and 5.8 per cent. by the camp surgeons as physically unfit for general military service, a total of 34.19 per cent.

The first draft was necessarily a rather coarse, hurried sifting of the fit from the unfit, and usually did not go beyond the defect sufficient to warrant rejection. The large percentage of abnormalities discovered in men from twenty-one to thirty-one years of age is the rate of the determining cause of rejection and is inconclusive as to the coexistence of other surgical or pathological conditions. For example, for such causes as hernia, goiter or flat foot, quickly discovered defects, the statistics of the draft boards are convincing, but for tuberculosis in individuals with goiter or heart disease in men with hernia, they are incomplete.

The evidence available indicates fifty to sixty per cent. of the men between thirty-one and forty-six years of age could not have passed for general military service if the physical requirements had remained unchanged.

The physical findings of the first draft to the public has proved an unpleasant revelation; to the student of preventive medicine the fulfilment of a prophecy. An examination of the causes of rejection in reference to origin and manner of development shows that many could have been easily prevented, readily corrected, or promptly cured. In fact, we are so far

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beneath our ability to increase the vigor, efficiency and happiness of the race as to appear to be still within the shadows of the dark ages.

Causes for Physical Disqualification by Camp Surgeons

It should be borne in mind that the statistics of the Report of the Provost Marshal General are based upon ten thousand two hundred fifty-eight records spread over eight camps. The percentage of disqualification at camp varied between seventy-two hundredths per cent. to eleven and eighty-seven hundredths per cent. (average five and eight tenths per cent.) under the first draft, which was smaller than the national average (seven and six tenths per cent.) for the period February 10 to September, 1918. The variation is due both to differences in standards observed by examining surgeons, and to the region of the country from which the recruits are drawn.

TABLE I

Causes for Physical Rejection by Camp Surgeons—National Army Experience Under First Draft of the Selective Service Act of 1917

Causes for Physical Rejection	Number	Per Cent.
Eye	2,224	21.68
Teeth	871	8.50
Hernia	766	7.47
Ear	609	5.94
Heart disease	602	5.87
Tuberculosis	551	5.37
Mentally deficient	465	4.53
Genito-urinary (venereal)	438	4.27
Physical undevelopment	416	4.06
Nervous disorders (general and local)	387	3.77
Flatfoot	375	3.65
Joints	346	3.37
Bones	304	2.96
Blood vessels	191	1.86
Underweight	163	1.59
Respiratory	161	1.56
Genito-urinary (non-venereal)	142	1.39
Skin	118	1.15
Ill-defined or not specified	93	.91
Digestive	82	.80
Alcoholism and drug habit	79	.77
Muscles	66	.64
Not stated	809	7.89
Total number of cases of physical rejections considered	10,258	100.00

Table I. shows that thirty-six and twelve hundredths per cent. of all rejections were due to defects of the eye, the ear and the teeth; eleven and twelve hundredths per cent. to hernia and flat foot; five and sixty-five hundredths per cent. to underdevelopment and underweight; five and thirty-seven hundredths per cent of the total to tuberculosis.

We need only to consider the causes of disqualification for military service in connection with the physical defects of school children to see the close relation of the one to the other.

Diseases and Defects of the Eye

Over one fifth (twenty-one and sixty-eight hundredths per cent.) of the physical disqualifications for military service was due to disease of the eye. Gonorrhea, syphilis, trachoma and the accidents of carelessness and ignorance—preventable causes—are responsible for forty per cent. of all blindness. Eliminate these and we may close four of every ten of our institutions for the blind and use their maintenance funds for a necessary charity.

As causes of impaired vision, uncorrected astigmatism, short-sightedness and squint aggravated by close work are of the first importance. Dufour has shown that the number of pupils with myopia and the average degree of shortsightedness increase from class to class and with the addition in school demands. This form of myopia is usually primarily due to congenital astigmatism, a very common condition, and the consequent strain upon the accommodation of the eye in the effort to see. Risley has reported a series of cases in which astigmatic eyes had passed, while under his observation, from hypermetropic to myopic refraction.

Neglected squint is an important factor in the serious impairment and destruction of vision. The bad advice to parents that the child beginning to squint will grow out of it, frequently has led to delay until the eye was blind. If the serious consequences of procrastination were known, children would be no more neglected than if they had appendicitis or diphtheria.

Rigid enforcement of the law relative to safeguarding the eyes at birth and to the control of venereal diseases and trachoma will save many eyes. Workers in occupations where eye injuries are common should be required to use proper methods of protection. No child should be permitted to begin school until his eyes have been examined by a competent oculist. When, for economic reasons, parents are unable to have him consult an ophthalmologist, the school board should make pro-

visions for his eye examinations. It will be better for society and cheaper for the state to provide glasses to correct errors of refraction than to bear the expense of class repetition, retardation or the result of delinquency, to which the eye defect may be a secondary but determining factor.

Diseases of the Ear

Diseases of the ear were responsible for five and ninety-four hundredths per cent. of the rejections. With few exceptions, auditory defects were the reason for disqualification. Middle-ear disease, which causes eighty-five to ninety per cent. of all deafness, usually has its origin in the nasopharynx and the Eustachian tube. Approximately thirty per cent. of the deafness in the United States is due to the suppuration of the middle ear during childhood. Ten per cent. of the discharging ears of children are complications of scarlet fever, measles, or other communicable diseases; in ninety per cent. diseased tonsils and adenoids are predisposing causes. In a systematic oral examination of patients with adenoids, Tomlinson found some grade of ear involvement in seventy-five per cent.

Where the function of hearing is impaired, the mentality of the child suffers. He becomes inattentive, in many instances diffident, and frequently a class repeater. Partial deafness, especially when it dates from childhood, is a disadvantage that seldom permits the individual to attain the efficiency of which he would be otherwise capable.

Much deafness would be avoided if diseases of the ear were promptly treated by specialists and if parents would see that the adenoids and enlarged tonsils of their children received proper attention. Medical inspection of schools and free treatment for children with disease of the nose, throat and ear whose parents are unable to provide medical care for them should be an important part of any program for the prevention of deafness.

Defective and Carious Teeth

Rejection of eight and five tenths per cent. of the registrants on account of their teeth occasions no surprise in a nation where decayed teeth is a disease of the masses and where seventy to ninety per cent. of school children have defective teeth. Had military requirements of previous wars been observed, a much larger per cent. would have been disqualified. The loss of a number of teeth both causes deformity of the face and impairs digestion by decreasing the ability of the individual to

masticate his food. The pus pockets and root abscesses are a serious menace to general health.

Instruction in oral hygiene, the examination of teeth of school children at least twice a year and a public clinic for the benefit of those unable to consult a private dentist would give the coming generation a digestion, a set of teeth, and a beauty of countenance unequaled by any of its predecessors.

Hernia

Hernia was the cause of seven and forty-seven hundredths per cent. of all rejections. A number of the ruptures encountered are congenital or are superinduced by anatomical abnormalities. Chronic constipation, faulty posture, lack of exercise and improper clothing, with resulting flabby abdominal muscles, and sudden strain are important factors in its production. Hernia to a considerable degree is preventable. Its presence is proof of neglected surgery.

Flat Feet

If flat feet were considered and treated with reference to their predisposing causes, physical rejection on their account would be much less than three and sixty-five hundredths per cent. Flat feet should be recognized as weak feet before flattening of the long arch has developed and the usual train of symptoms are present. The body weight normally passes slightly to the inner side of the center of the knee, through a line prolonged from the crest of the tibia, through the ankle, over the dorsum of the foot to the second toe. With the beginning of eversion of the foot and the change of direction of the body weight, it is only a question of time before the symptoms and signs of flat foot become evident.

The importance of muscle insufficiency, improper nutrition and communicable disease in the production of flat foot are shown in the following table, taken from the statistics of Ehrenfried:

Children under twelve years of age examined	1,000
Children with debility of the feet	440
Congenital—club-foot	18
Idiopathic—physical debility	95
Secondary, due to some other condition	327
A. Rickets	200
B. Cases of unsuspected infantile paralysis	107

Undevelopment and Underweight

It creates no surprise that poor general physical condition accounted for five and thirty-seven hundredths per cent. of the rejections, when it is known that from fifteen to twenty-five per cent. of the school children suffer from malnutrition. Defective sight, deafness, difficult breathing caused by adenoids and nasal obstructions, enlarged tonsils, contagious diseases, and insanitary home surroundings are preventives and deterrents of normal growth.

Regardless of whether physical subnormality is an expression of one or a combination of these causes, it is preventable and correctable. Its presence in a large per cent. of the population is a reflection on our civilization and a menace to the future welfare of the nation. An efficient system of child welfare, medical inspection of schools, school lunches and physical education throughout school attendance would insure the proper development of children to adults. An attempt to teach an undernourished child is an attempt to decorate before laying the foundation. The small cost of the school lunch, in most instances, should be borne by the child; if necessary, it should be paid for by the school. The better work of the child and the instructional value of the lunch would well repay the trouble of preparation and the expense.

The same undevelopment, bad home conditions and physical handicaps which contribute so largely to the production of substandard individuals create pressing problems for the teacher, the physician, the sociologist and the penologist. The physically defective individual, denied his inalienable rights of adequate food, healthful environment and proper medical care falls an easy prey to disease, may develop anti-social tendencies, or, as industrial flotsam, often settles along the shores of endeavor, a hindrance to the launching of enterprise.

Physical Defects and Delinquency

The loss or impairment of an organ destroys or decreases the efficiency of the harmonious interaction of the other organs of the body, and continued existence is the result of readjustment. The resulting reaccommodation not only affects the physical personality, but it may also give rise to deviation from normal mental reaction. We are unable to estimate the exact part played by defects of the ears and eyes, diseased tonsils and adenoids, in the production of truancy and delinquency. Neither are we able to determine the relation of undernutrition and anemia to incorrigibility. We do know, however, that physical

defects and undernourishment may be the precipitating cause, when associated with such contributing factors as defective ancestral germ-plasm and oppressive environment. One individual in good surroundings and well nourished, with a stable nervous system, may survive the misfortune of his physical handicap; while a physical defect in another with an already overtaxed brain may produce such nervous irritation as to give rise to mental abnormality or antisocial tendencies.

Physical Fitness of Women

While we have available no such extensive statistics for women as for men, fragmentary evidence and comparison of the findings of the medical inspectors of schools in the case of boys and girls do not indicate that women are of better general physique than men. All the major causes for physical disqualification under the draft are by no means peculiar to the male and may occur in the female. The first draft, therefore, may also be considered a more or less accurate index of the physical development and defects of the women of the nation between the ages of twenty-one and thirty-one. From the view-point of racial vitality and progress the physical development of women is as essential as that of men—the prevention of disease and physical handicaps perhaps of greater importance.

Lest We Repeat

A survey of the causes of physical disqualification in men twenty-one to thirty-one years of age does not warrant extreme pessimism in regard to the physical deterioration of the manhood of the nation, as a number of the defects are anatomical, largely preventable, and do not indicate substandard general physical condition. They are, however, an overwhelming, unanswerable argument for the immediate adoption of a comprehensive system for the promotion of child welfare, for the medical supervision of schools, for instruction in hygiene, and for thorough physical training.

In this country 230,000 infants die annually. Before the war an infant had six or seventeen chances in a hundred of dying in the first year, depending on whether its father earned over twelve hundred fifty dollars or under four hundred fifty. One baby in twenty-five dies from diseases directly due the care and condition of its mother during pregnancy and confinement. The death rate among infants whose mothers go out to work is twice that of those whose mothers are able to remain at home

and care for them. Thousands of infants weather the first years of life battered and weakened, forever handicapped in becoming effective members of society. Poverty and ignorance underfeed from fifteen to twenty-five per cent. of the children of the nation. Tens of thousands of human beings are being reared in insanitary surroundings in which it is impossible for them to attain normal growth and health.

In spite of its importance, required systematic learning of hygiene, sanitation and physiology is an exception, even in our institutions of higher learning. The present legal requirements for these subjects in the elementary and secondary schools are inadequate and are in great need of immediate revision. Mind embellishment takes precedence over that knowledge which would safeguard health and prevent the loss of life. A system of education that does not prevent its finished product from blistering his arm with a pepper plaster or from pouring sulphur in his shoes to avoid influenza is no more successful than one that permits a student to graduate without a knowledge of mathematics or of language. The draft has taught that in developing a child the gymnasium and library, the classroom and the playground, the laboratory and the great outdoors are coordinate. It has shown that in moulding efficient citizens to support the nation in its hour of need the lowly sandwich, served in a school lunch room, and fresh air may be as valuable as the "rule of three." In other words, social effectiveness is equally dependent upon adequate mental and physical development. The most valuable individual to the state is he in whom the moral, physical and mental qualities are most highly developed, absolutely correlated and in perfect harmony. The need of the hour is that physiology, sanitation, hygiene and physical training should have place in our educational system, commensurate with their importance to the individual and to society.

Medical Inspection of Schools

Medical supervision of schools should include a school nurse service. It should apply to buildings and equipment, as well as to the mind and body of the children. About twenty million children, nearly one third of the population of the country, are compelled to spend, on an average, five hours a day in school one hundred sixty-five days in the year. Under such circumstances, as effective precautions should be taken to insure proper ventilation, lighting, heating, furniture and general sanitary conditions in the school as to provide for the child's physical welfare as to enforce its attendance. It is obviously unfair to re-

quire a child to occupy a seat likely to produce body deformity or to study in a light that may impair its vision, yet this is done throughout the nation. It is equally unjust to bring together a number of young persons at an age when most susceptible to communicable diseases without medical supervision, unless the school is to provide a great disease exchange for the community. In this connection it must be remembered that the twenty million children of elementary-school age come in contact, more or less intimately, with approximately twelve million others of preschool age. These younger children are very susceptible to infectious diseases and are in the age group in which eighty-five per cent. of the mortality occurs.

When medical inspection is carried out, a disease history of the child will be obtained on entry, and an enormous number of defects and functional diseases will be discovered that may be corrected. It will provide a careful medical record preliminary to physical training, will determine in what individual corrective gymnastics are needed, and, by its periodical examination, will ascertain the physical progress of the child. The community should realize, however, that it is of little value to spend money to discover defects unless provision is made to remedy them when they are found. Each school district should provide a dispensary service for school children and parents must be educated to save themselves expense by paying the family doctor a small sum to prevent, rather than a large sum to cure, illness in their children.

Physical Education

Physical education should have as its purpose the development of the functional power of the child to the highest level consistent with the most successful training of its intellect; it should meet the needs of the weak, who require it most, as well as of the strong; it should be graded for various ages; its progress should be determined by tests and measures of development, strength, agility, endurance and ability to do. Its proficiency should be based upon well-defined accomplishments and not upon one or two periods of exercise for a given time.

In general, provision must be made for the physical education of three classes of individuals: (1) the physically normal, (2) the subnormal, (3) the abnormal and physically defective.

The physically normal should not only be required to take general exercise, but should be encouraged to select some form of sport and to acquire a fondness for it. In the primary school it may mean games and outdoor exercise; in the high school or

college the development of an "athletic hobby" to keep him in "fighting trim" when required to lead a sedentary life.

The subnormal individual, underweight and understrength for his age, undeveloped but organically sound, will require special and general exercise to meet the tests of normal. Having shown his ability by passing the required efficiency tests of normal, he may be further educated as in the first class.

In the abnormal group we find individuals distorted as to posture or carriage, but who may become greatly improved or who may overcome their deformity by corrective gymnastics. In this class we also have the cripples and those with heart lesions, hernia, diseases of the joints, etc. A number of these individuals could be cured by proper surgery, and would be, if their parents were so advised by a medical inspector in whom they had confidence. All would be greatly benefited by special calisthenics and other light forms of exercise under medical supervision. In many instances members of this group have been led to attach too much importance to their condition. Nothing will do more than safe, beneficial exercise to lift them from the despair of chronic invalidism to the enthusiasm of physical well-being.

Physical education is a great antidote for antisocial tendencies. It teaches temperance, self-control, courage and endurance. It produces the ability to play the game to the end and to lose with a smile or to take victory with modesty and magnanimity. It Americanizes and de-hyphenizes by the democracy of the playground and by the catholicity of its games. It places the nation on the solid foundation of physical soundness, morality and vitality.

Reconstruction must mean a new day, a new courage—a new justice. Education must be revised to cultivate properly the body as well as the mind. The slaughter and crippling of infants by atrocious social conditions must cease. The underfed must be adequately nourished; children physically handicapped must receive medical care when the greatest number of cures are possible. The treatment of mental defectives must be inspired by scientific common sense rather than by ignorant and foolish sentiment. Living conditions must be those in which a human being can best live, grow and work.

THE EUGENIC ASPECT OF SELECTIVE CONSCRIPTION

By Dr. ROSWELL H. JOHNSON

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THE future of a nation depends to a certain extent upon the relative quality of those who survive a war and those who perish. Coming generations are produced in larger part by the non-combatant males, since a certain fraction of the combatants never return, and of those who do return, some are so incapacitated as to prevent marriage and parenthood. It therefore behooves us to inquire whether the method of selecting the group for this high percentage of mortality is such that the individuals are on the average higher than the average of the remainder of the same age and sex, or that they are of average quality, or that they are inferior. It is because this tremendously important question, which means so much to the future of our race, seems to have been viewed wholly from the standpoint of military efficiency, and administrative convenience, that it is desirable to consider here the neglected eugenic aspect.

First we must compare the eugenic results of enlistment *vs.* selective conscription. Voluntary enlistment is a definitely selective process, no less selective because it is by the will of the individuals. The individuals who have the will to enlist differ in the long run from those who do not have the will to enlist. Furthermore, this will to enlist is associated in different wars with different qualities. In the Spanish War it is probable that the love of adventure played a larger part on the whole than in the Civil War or the Great War. When a country is not suffering invasion the enlistments are of a somewhat different type of men from when it is. What is especially important for our purpose is a consideration of the extent to which idealism is effective. The more idealistic the aims of a war, the more important it is that selective conscription should replace enlistment early and completely.

Conceding then the superiority of selective conscription, what should be the basis of selection, having reference both to military efficiency and to post-bellum results?

Arbitrary limits of little selective importance should be

avoided, as the larger the range from which one may select, the more discriminating the possible selection. Thus the draft age limit should have been from 19 to 40 years from the outset of the Great War. The exemption of the married, however, so long as military exigencies permit, is desirable from a eugenic standpoint as well as from various social and military considerations.

Exemptions on physical grounds are of course necessary for military reasons, but except for certain defects of no eugenic significance, should be kept as few as feasible, for such exemptions on the whole have a dysgenic effect by lowering the relative mortality of the exempts, since their physical inferiority would be in some cases inherited to some degree. The exemption of those suffering from diseases or defects which are curable without too great an expense or too long a period should be discontinued, and an attempt should be made to restore such cases in special restoration camps. Otherwise some inferior groups will contribute unduly to the next generation.

But it is of course the mental (including the moral) attributes which are of major concern from the standpoint of post-bellum results. Necessarily there must be an exemption of the highly unsuitable or markedly mental defective since their uncertain conduct might endanger the lives of their associates. On the other hand, the exemption of the merely dull-minded who can be useful in digging, carrying and handling supplies under supervision would be a serious error by saving for survival this group at the expense of their superiors.

Second, where a type of service or a detail for a special purpose is especially hazardous, selection should be for the special qualities needed and should exclude those who are also highly superior in a wide range of qualities which are not needed. It is at this point that the current methods are most faulty. For instance, in the aviation service, the candidate, besides passing some necessary physical tests, must in general have been a college student. Mental tests for special qualities needed in aviation should be elaborated at once to supplant the present crude and socially and racially damaging method of selection.

While selection for especially hazardous tasks by volunteering can not be wholly abandoned, in general, the officers should select the men with reference to the particular quality needed for the particular assignment and should avoid choosing men who are far better for other assignments, but not better for the assignment in question.

Officers must necessarily be a select group for reasons of military efficiency. For this same reason, the enemy wishes to eliminate them. Care should therefore be taken to conceal their identity when exposed to the enemy, and to limit such exposure in so far as military efficiency permits. Officers of no higher rank than necessary should be permitted to accompany small parties on extra hazardous details.

The use of the present questionnaire for the selection of draftees is vastly superior to the far cruder method at first employed. Especially to be commended from the eugenic as well as the social standpoint is the placing of technical experts and important executives in late classes.

Unfortunately in the stress of war needs there is a natural tendency to lose sight of ultimate results at the very time when such results are most seriously at stake.

THE TRAIL THROUGH THE RAIN FOREST BENEATH THE MOSS, BESIDE THE FERNS.

THE FERNS OF THE RAIN-FOREST

By CLIFFORD H. FARR, Ph.D.

WILLIAM BAYARD CUTTING TRAVELING FELLOW OF COLUMBIA UNIVERSITY

THE marvel of the vegetation of the tropical rain-forest is the tree-fern. A tree in form and size and a fern in structure, this plant has been indeed aptly named. Its stem stands erect in the midst of the jungle to a height of fifty feet in some instances, and its few large leaves form a crown at the top very much like that of the palm. But tree-ferns are even more beautiful than the royal palm, the most stately of that group. The leaves are more finely divided, delicate and lace-like, and are arranged in a perfect rosette; and the stem, far more slender and graceful, has its surface moulded into a unique pattern as if in terra cotta.

Tree-ferns are exceedingly choice in selecting their dwelling places, and refuse to endure any sort of rigorous environment. In fact, they grow in the most evenly tempered climates in the world. The average temperature of their habitat in Jamaica is about sixty degrees Fahrenheit, and no variation of

THE LARGE-LEAVED *Alsophila pruniata*.

LOOKING UP A RAVINE.
Climbing Ferns to the right.

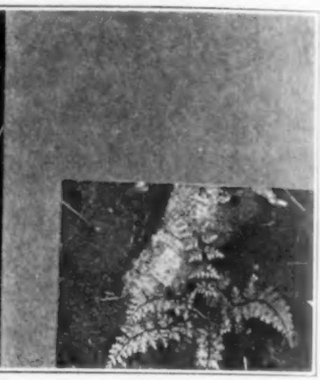
more than sixteen degrees above or below occurs throughout the entire year. There are thus no cold winters nor hot summers with which to contend; and likewise there are no long periods of drought usually, for the tree-fern grows where it rains almost every day. The moisture-laden trade winds strike against the north side of the Blue Mountains of Jamaica at an elevation of about one thousand feet and slowly creep up their slopes, the moisture precipitating as it cools. It is on such slopes as these, at an altitude of about five thousand feet, that the tree-fern is at its best. Here the minimum annual rainfall is about sixty inches and the maximum about two hundred. Not only does the tree-fern require a very moderate temperature and a large amount of moisture both in the soil and air, but it is also not adapted to withstand strong winds. Its slender, unbranched stem, only two or three inches thick and many feet in height, is extremely frail in comparison with the trunks of other trees. Consequently, it must hide itself in the

depths of narrow ravines through which only gentle zephyrs move. Nor does the direct intense light of the tropical sun usually fall upon most members of this group through long periods, for other trees and perpetually veiling clouds shield them from its actinic rays. Despite the fact that light is an essential to plant activity, these curious forms, unlike other trees, do not continue to flourish when direct sunlight strikes them day after day. It is probably not the light of the sun, but rather the heat which does injury to these plants. Long before the engineer discovered that heat rays might be separated from light rays by interposing a water screen, these ferns were enjoying the beneficent activity of the ever-present clouds in absorbing the thermal portion of the solar radiation while transmitting a large proportion of its light.

In fact, the tree-fern lives under very nearly perfect conditions from the standpoint of a plant. There must be moderate uniform temperatures, abundance of soil moisture, high humidity, freedom from strong air currents, and a maximum amount

Walking Fern with Drop of Water on Tip.

The Silver Fern.



The Golden Fern.

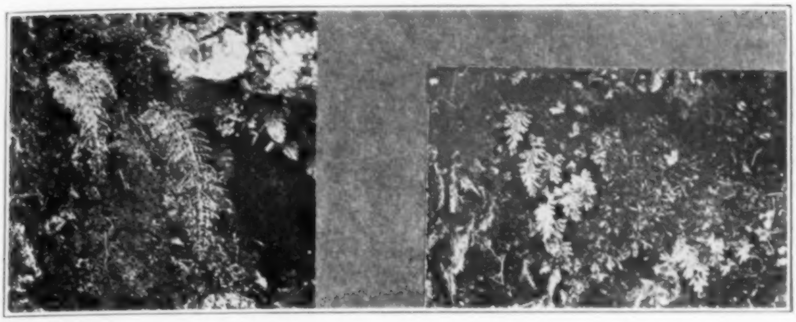
The Black Fern.

Like the Wings of a Bird.

FERNS OF MANY FORMS AND COLORS.

of light. Only the mountain rain-forest of the tropics can afford this ideal combination of environmental factors. Here of all places is the paradise of ferns. Ferns carpet the floor of the forest and the walls of the steep-sided ravines. There are walking-ferns with the tips of their leaves projecting into a long beak, curled at the end. Water repeatedly falling collects in a drop on this little curl, and within this drop of water a bud develops. As this bud increases in size and weight, the leaf bends over, finally touching the ground where the new plant can start life independently.

Then there are black ferns, the backs of their leaves densely covered with black reproductive bodies, known as spores. There is the silver fern too, but the white color of the under surface of its frond is due to air within and among the minute hairs which grow there. A similar cause is responsible for the gilded appearance of the under side of the leaf of the golden fern. Some ferns are very harsh and form dense, almost im-



The most delicate. *Hymenophyllum polyanthos.*

The smallest. *Hymenophyllum fucoides.*

On a Moss-covered Log. *Trichomanes crispum.*

Lacelike though sharp and harsh. *Trichomanes rigidum.*

FILMY FERNS.

passable thickets; such are the hogferry, rambling fern and certain species of forked ferns. Others climb the trunks of trees, or perch on the branches. But the tree-fern, the aristocrat among them, stands head and shoulders above all its kinfolk, both in stature and in esthetic grandeur.

In the old world tree-ferns are distributed between 47° south and 32° north latitude; a few are found in the extreme southern portion of Japan. They are most abundant, however, in Australia and the Pacific Islands, though fairly numerous in Ceylon, Java and New Zealand. The starchy pith of some of the New Zealand species is used as food, or is fermented and shipped to India, where it is consumed as an intoxicating beverage called "Ruckschi." In the western hemisphere their range is more limited, from about 44° south to 25° north latitude. The Hawaiian Islands and the Antilles, the Andes and Central America have many forms, but they especially abound

FERNS OF MANY SIZES BY THE WAYSIDE.

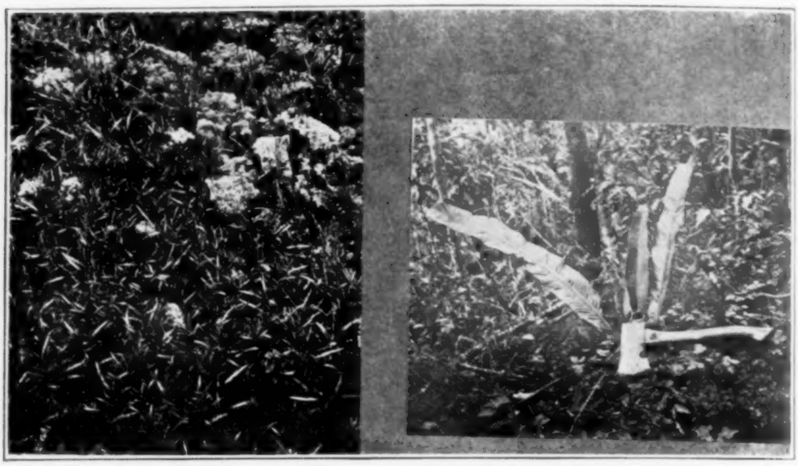
on the island of Jamaica. Dr. Forrest Shreve has made a special study of climatic conditions in their habitat in Jamaica, and his interesting results were published by the Carnegie Institution of Washington in 1914.

Tree-ferns belong to a single family known as the Cyatheaceæ, of which there are about two hundred species. Not all of these species, however, are tree-ferns, but many have a horizontal stem, as do ordinary ferns. These two hundred species are grouped into four genera: *Cyathea*, *Alsophila*, *Dicksonia* and *Hemitelia*. Of the last-named genus the tallest is *Hemitelia Smithii*, growing in New Zealand to a height of less than twenty feet. *Cyathea* reaches its greatest development in Jamaica, where the stems of two species, *furfuracea* and *pubescens*, may measure more than forty feet. The maximum height of *Dicksonia* is attained in Australia, where *Dicksonia antarctica* is found at times to be at least sixty feet. In this same region grows the tallest of them all, *Alsophila excelsa*, which has been reported to lift its crown as much as eighty feet above the ground.

The stems of tree-ferns rarely branch. When they do, it is not a branching at right angles, but a dichotomous forking of the main stem, resulting in two crowns of leaves. In some species the leaves remain attached to the stem after they have died, completely hiding it. Usually, however, after the work of food-manufacture and spore-formation is finished the leaf breaks away, leaving a scar which may be a half inch or more in diameter. It is slightly oval and, like a cameo, elevated above the surface of the stem. Every leaf-scar has markings symmetrically arranged in some sort of pattern characteristic of the species. These markings are a series of pores or tubes through which water was carried upward to the leaves and food materials downward to the roots. In *Cyathea furfuracea* a circle of twenty of these ducts, equally spaced, lies just inside the margin of the leaf-scar. Within this circle is a smooth triangular area bounded by eight more pores, the apex of the triangle pointing downward.

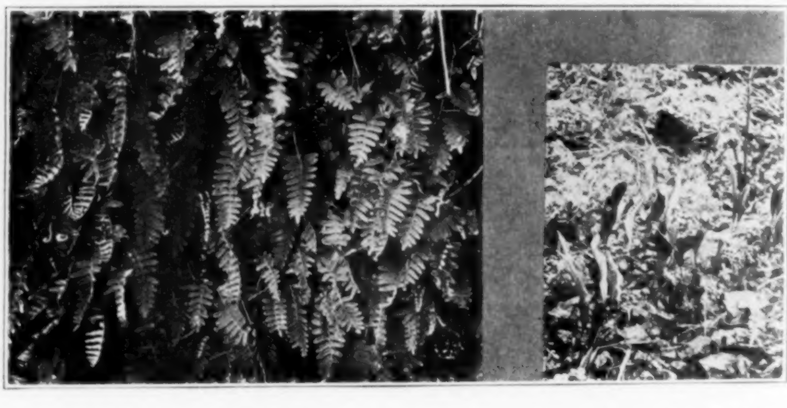
These scars are arranged in seven longitudinal rows up and down the stem, slightly winding about it in a sort of loose spiral. This spiral is undoubtedly brought about by the torsion of the stem during growth, the rigidity of the stem being so great that it could not have been twisted after once being formed.

The area between the leaf-scars is covered with two kinds of structures: the ramentum and the roots. The former, characteristic of most ferns, consists of brown chaff-like scales an inch or more in length. They envelop the young leaves and roots, protecting them in their early stages. In all ferns the



The Smallest
Mixed with Spongy Lichens.

The Largest.
Pessopteris crassifolia.



Hanging over a Rocky Cliff.
Note fruit-dots on under surface.

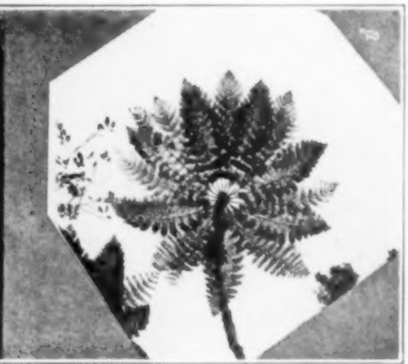
Rambling over the Rocks
amidst the Strawberry Leaves.

ENTIRE-LEAVED FERNS AND A *Polypodium.*

roots grow out between the leaf bases. The tree-fern thus has no tap root at the base of the stem, nor is the latter deeply sunken in the ground; hence, the necessity for tree-ferns to avoid windy places. The lower end of the stem is located almost on the top of the ground and the only means of support and anchorage are the numerous small roots which clothe its base. They are of about uniform diameter, rarely exceeding a fifth of an inch, and about twenty or thirty are produced around each leaf base. As the stem grows progressively upward, new roots are formed between the new leaf bases and grow down over the roots below, weaving in and out among them, forming


A Thicket of *Dicranopteris*.

Two Species of *Dicranopteris*, and a Bracken fern below.

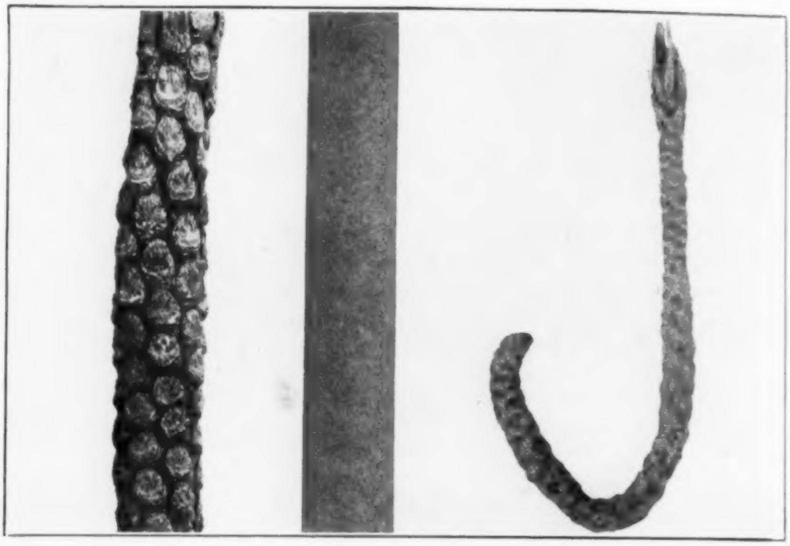
A Thorny Vine. *Odontosorea jenmanni*.

A *Dicranopteris pectinata*, showing the forking.

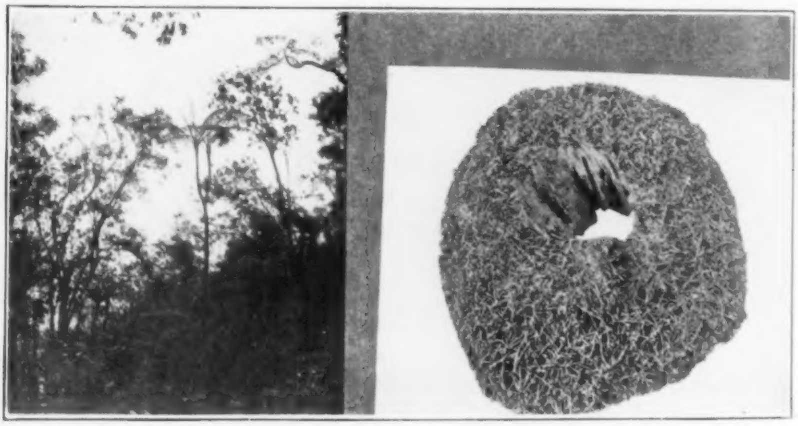
FORKED LEAVES AND RAMBLERS.

a compact entanglement, which at the base of the tree may become several inches thick.

This curious method of root development gives rise to some very interesting features in the life of this plant. The older roots, as well as the base of the stem, die, though they do not decay, so that the water for the leaves is carried by the younger roots for several feet above the ground on the outside instead of the inside of the stem. There is thus a greater amount of moisture required in the soil and in the air to compensate for the loss which is undoubtedly involved in the great exposure of the conductive tracts. On the other hand, this is an ingenious means of multiplying the number of conductive tubes, in the absence of cambium, to enlarge the stem. Furthermore, by the continued formation of new roots, the older ones may be dis-



Leaf Scars. Crooked by tumbling.



Rarely does it fork. The roots that clothe the base.

THE STEM OF THE TREE-FERN.

carded as soon as they cease to function without impairing the supply of water to the leaves. At the same time, the dead tissue of the roots and stem is utilized for support and for protection of the new roots.

Another beneficial feature of this mode of development of roots is shown when an accident has befallen the plant. Tree-ferns are especially liable to fall, both because of their slight anchorage and the great erosion due to the steepness of the slopes and the almost incessant rainfall. When a tree-fern falls

The Spreading Level Leaves. The Silhouette against the clouded sky.

The Monarch of the Jungle. Forty feet above the Soil.

THE CROWN OF THE TREE-FERNS.

upon its side, the new growth takes place in a vertical direction, forming an angle with the fallen portion. The new roots pass directly into the soil, leaving the prostrate portion of the stem entirely useless. The accompanying photograph shows a stem to which at least three such mishaps had occurred. When the writer found it, the base of the stem was projecting away from the soil, and only a few weak roots were keeping it from rolling still farther down the hillside.

The leaves of tree-ferns are always quite large. In *Alsophila pruniata* they frequently measure sixteen to eighteen feet, forming perfect arches beneath which one may walk without disturbing a single leaflet. The main axis of some of the fronds of a South American species are said to be as much as eighteen

The Zone along the Mountain's Side.

meters, but this statement may be an exaggeration. The rachis bearing the leaflets may branch as much as six or seven times. Upon the under surface of these leaflets are borne the reproductive bodies, or sori. In *Cyathea* these are tiny smooth brown spheres within which are the numerous sporangia containing spores. In *Hemitelia* the sorus is cup-shaped, more than filled with sporangia. In *Dicksonia* it consists of two valves operating on a hinge. In *Alsophila* there is no covering for the sporangia which are simply grouped together in spherical clusters.

The young leaves are rolled in the bud in the form of a watch-spring, which is sometimes several inches in diameter. The inner coils are almost completely veiled from view by the chocolate-colored hair-like ramentum. The leaf gradually unrolls and each of the secondary branches is likewise seen to be coiled. Thus there comes to be a coil on the end of the main rachis and on each of its lateral branches. The growing tissue is within this coil and from it all parts of the leaf are produced. The strengthening tissue is the last to appear and, consequently, the coil hangs pendant from the tips of the leaf, giving the whole a drooping, wilted appearance. During the unrolling of the leaf the rachis is almost vertical, but as it grows older it bends more and more toward the horizontal. When this position is reached in most species the spores are shed, and then the leaf continues to bend downward, finally dropping off. This procedure is very similar to palm leaves, though the latter have no spores, and the leaves are formed singly. In the tree-fern there is a rosette of four or more passing through the series of changes simultaneously, and followed somewhat later by another set. Sometimes two or three sets may be seen in different stages at the same time.

It is a beautiful sight to behold, from the hillside above, these huge crowns with their delicate lacelike leaves, the leaflets all turgid and in a single plane. But the master picture is for him who looks, not earthward, but heavenward. As you walk through the jungle your eyes glance upward and behold a wonderful vision, a symmetrical silhouette of the enormous rosette against the soft background of the clouded sky. The fronds radiating from the apex of the stem like the points of a star present a distinctly artistic pattern. Go to the art institutes and museums of the world, you can not match this. This was modeled by a sculptor whose touch is infinitely more delicate than the clumsy fingers of the most skilled of human artists. Silently you marvel at the splendor, and with Browning,

> Look through Nature, up to Nature's God.

THE DEVELOPMENT OF CONCEPTIONS OF PHOTOSYNTHESIS SINCE INGEN-HOUSZ

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THE various functions of a plant are so closely interdependent that it is impossible to study rationally any one activity without taking into consideration a number of others. It is constantly becoming more evident that imbibition, metabolism, growth, photosynthesis and transpiration are to a greater or less extent all interrelated, a study of the one requiring a knowledge of all the others. The physiological arrangements in vegetable organs are not obvious to the eye, they can be ascertained only by the application of a variety of methods, observational and experimental. These methods make use of a great number of different physical and chemical principles, the nature of which have been more or less definitely established, and in terms of which we now endeavor to interpret the actions of living things. The correlation of physical and chemical actions is of itself a difficult task, but when such actions have their seat of activity in living things, the task becomes tremendously difficult. Physiology is a great deal more than applied physics and chemistry. We must, however, rely upon these disciplines in order to form conceptions of the various vital phenomena, as operations of known causes. Thus these sciences have given us a vocabulary, while the true foundation of physiology will always be the direct observation of vital phenomena. The fundamental principles of the process of the utilization of the carbon dioxid of the air by the chlorophyllous leaf through the action of light, were established with almost no aid from physics and chemistry. Such an understanding of the phenomenon as we now possess has been possible only through the application of various physical and chemical facts. But photosynthesis is an exceedingly complex process, involving many factors and agents, all of which must be placed in proper relationship before a complete understanding can be hoped for.

It is not my purpose here to enter upon an elaborate historical discussion of the development of the ideas and theories relative to this subject. This is in itself a most fascinating and almost endless study, revealing often the most grotesque and

fanciful speculations of which the human mind has been capable. As in the history of every science, the carefully executed and exactly recorded experiments stand out as bright beacons to guide the workers in later generations. In no other way, perhaps, is the importance of reasoning only from careful experimentation and observation in order to gain light on the phenomena of nature brought home to one so clearly as by perusing the immensely prolix and speculative writings of most of the earlier workers. However, this fault is not entirely confined to our ancestors. In connecting the name of Ingen-Housz with the beginning of the development of photosynthesis, I do not mean to give all honor to one man. He stands as the representative of a group of highly-gifted investigators of a certain period and as is the case in all questions of this nature, each contributed a valuable portion to the whole. I purposely avoid discussion of the unfortunate and prolonged polemics which occurred at this time, a time-consuming study not altogether conducive to hero worship. However, from a plant physiological viewpoint and in the light of our present knowledge, the name of Ingen-Housz does stand out above his contemporaries as grasping the essentials of the cosmical function of plants. His little book of about 150 pages, "Experiments upon Vegetables," published 140 years ago, is one of the great classics of experimental plant physiology.

What then, briefly, was the status of the subject as found by Ingen-Housz and his contemporaries? Practically all of the work prior to this time was guided by the Aristotelian dictum that plants derive their nutrition from the soil. Against this mass of incongruous speculation there stand a few beautiful and classical observations. The great iatrochemist, van Helmont, endowed with extraordinary clearness of perception, denied the Aristotelian doctrine of the composition of organic matter and considered water the chief constituent thereof. His classical experiment is probably well known to all. In a pot he placed 200 pounds of thoroughly desiccated soil and planted therein a willow twig weighing 5 pounds. This was protected from dust and watered daily with rain-water. After five years the plant had enlarged greatly, and increased in weight by 164 pounds, while the earth, after desiccation, showed a loss of only 2 ounces. And almost three hundred years later Liebig was still fighting the humus theory of nutrition!

Probably the first to express the idea that the leaves are the organs which produce the substances necessary for the develop-

ment of the plant was the Italian, Malphigi, in the seventeenth century. He considered the chief function of the leaves to be the digestion of the nutrient sap rising from the roots. This process of digestion in the leaves was considered essential for the development of the plant, as was shown by the deleterious effect of removing the cotyledons (which he regarded as true leaves). He noticed, furthermore, that in the leaves are openings, "which," he says, "pour out either air or moisture," though it is quite evident that Malphigi did not recognize the other function of the stomata, namely, the absorption of gases. Grew in 1676 also pointed out the existence of stomata.

In considering the work on photosynthesis of this time, it must be borne in mind that the most confused and contradictory opinions prevailed as to the composition of the atmosphere. It is difficult to imagine the chaos which existed on a subject which now seems to us so simple. All the more remarkable are the observations of that brilliant investigator, Stephen Hales. He concluded that plants draw some part of their nourishment through their leaves from the atmosphere, and he was also the first to suggest the influence of light. A contemporary of Newton, Hales regarded light as a substance and asks "may not light which makes its way into the outer surfaces of leaves and flowers contribute much to the refining of substances in the plant?"

And finally there may be mentioned also the observations of Bonnet, who was the first to record the evolution of gas from submerged illuminated leaves, but he was not able to interpret properly his observations.

Priestley had noticed that plants confined in an atmosphere rich in fixed air (carbon dioxid) produced in the course of some time large quantities of dephlogisticated air (oxygen). Priestley explained the phenomena as caused by the growth of the plant and elaborated his discovery in relation to the cosmical function of vegetation. Schelle, working in Sweden, who had discovered oxygen simultaneously with Priestley, reported quite the opposite results; his plants produced fixed air (carbon dioxid) and he challenged the correctness of Priestley's results. On repeating his investigations, Priestley himself became confused through the irregular outcome of his experiments, looking always simply to the growth of the plant, and finally practically refuted his original statement.

Jean Ingen-Housz, an eminent physician, interested primarily in the influence of foul and pure air on the health of man, became enthused by the reports of the influence of oxygen

on living things. Schelle had shown that atmospheric air was composed of about[1] two parts of nitrogen, one part of oxygen and a small quantity of carbon dioxid. But the latter gas was also considered an element, though it was known that it was exhaled by animals, as was also its physiological property that it would not support life. Ingen-Housz was started on his investigations by Priestley's announcement that growing plants produce oxygen. He was, however, much more fortunate than Priestley in his experimentation. He soon saw that the mere growth of a plant had nothing to do with the purification of the air. His experiments are a masterpiece of manipulation and self-criticism. Step by step he approached the correct interpretation. It was the effect of the sunlight on the plant which produced the oxygen and this was due to the light, not the heat, which the sun radiates; and only in the light did the action take place, while the green leaves only were capable of this action. The carbon dioxid came from the atmosphere and the oxygen escaped through the stomata. High concentrations of CO_2 were toxic to the plant, and in the dark or even in the shade, not oxygen, but CO_2 was evolved. The contradictory results of Priestley and of Schelle were explained. Thus did Ingen-Housz grasp the very fundamentals of the process.

In 1784 Lavoisier established the composition of carbon dioxid and the nature of combustion. At this time the battle of opinions regarding these processes was at its height, and the value of Lavoisier's discovery was unheeded even by Ingen-Housz. But in his second publication he saw the matter clearly. The source of the oxygen was the carbon dioxid, the combustible matter of the plant was thus formed, van Helmont's experiment was explained, and the organism was seen to live by the burning of the material which it had itself formed. But there were also contributions from other workers; none of them, however, had the same clarity of vision and could distinguish between the two functions proceeding simultaneously, photosynthesis and respiration, nor made use of the modern conception of the composition of carbon dioxid. Sénébier executed extensive experiments and published voluminous elaborations. He showed how photosynthesis was affected by temperature, and by means of his well-known colored bell jars ascribed the chief action to the red rays of the spectrum. But the old Aristotelian dictum persisted; the roots were supposed to supply the leaves with solu-

[1] Black, Joseph, "Lectures on the Elements of Chemistry," 1st Am. ed. from last London ed., 1806, 2: 344.

tions of carbon dioxid. This was not definitely eradicated until the work of Moll and of Bousingault with pure water cultures.

As in all questions of this nature, so here it is also almost impossible to definitely establish who was the first to observe the utilization of carbon dioxid by the plant. Technically the honor probably belongs to Henry and Persival, though our present knowledge undoubtedly comes directly from Ingen-Housz and Sénébier. Although Ingen-Housz clearly described the phenomenon of CO_2 evolution both aerobically and anaerobically, it is surprising how long the erroneous conceptions regarding these processes persisted.

And finally to this period belongs the work of de Saussure. Though a contemporary of Ingen-Housz, Sénébier and Priestley, de Saussure attacked the problem a few years later. Perhaps nowhere else is there such a clear example of the tremendous change which had been wrought by the new chemistry of Lavoisier. From the style of thought and presentation, there might be a century between de Saussure and his contemporaries who had worked on this problem. De Saussure's conceptions of the composition of air, the nature of burning and the composition of water were clear and based upon definite experimentation. He worked entirely quantitatively; he asked a certain question and got a definite answer, and thus he established the quantitative relations of the phenomena which Ingen-Housz, Priestley, Sénébier and a few others had described, besides several new discoveries, more especially the rôle which water plays in the process of photosynthesis. De Saussure spoke a new language and followed a new system of thought. In fact, his work naturally would mark the beginning of a new era. But alas, it also marks the beginning of a rapid decline, both in investigation and in the presentation of existing knowledge on the whole subject of plant nutrition. A perusal of the textbooks as they appeared from about 1815, with a very few exceptions, reveal such unpardonable inaccuracy, indifference and simple ignorance as to be quite incomprehensible in view of the enormous importance of this phenomenon to human welfare. Most of the modern texts of plant physiology and physiological chemistry by no means escape this criticism. The beautiful experiments of the men just referred to were either forgotten or directly misinterpreted. The works of Dutrochet, Sachs and Pfeffer may be cited as the few great exceptions.

Aside from the discovery of certain details of the process of photosynthesis regarding the easily detectable products and the influence of certain exterior factors, the status of our knowledge is practically as de Saussure left it over 100 years ago!

What then are the causes of this lamentable stagnation, this apparent indifference to a branch of science which deals with a phenomenon upon which our very existence depends? It is not, I believe, to any one cause or condition that the situation can be attributed. We are not guilty of following an erroneous doctrine or system of thought. But the difficulty rather lies in the great complexity of the subject itself.

Among the botanists of the time the discoveries of Ingen-Housz and his contemporaries found no interest. This was at the time when Linné determined the course of botanical thought. There was at the time no such discipline as plant physiology; Hales, Ingen-Housz, Priestley, Sénébier, de Saussure were not botanists, but physicists and chemists. Here is an example of the deplorable results arising from the unfortunate sharp division of the various fields of science. Botany was not developing a symmetrical structure, but a highly lopsided one with attention restricted to the description and classification of plants. Cuvier, the great academician, one of the most illustrious men of that glorious age when France was truly the home of science, who did so much for botany, especially for its wide study and culture, utterly neglected the functional and nutritional phase. Nor did Humboldt, in spite of his unusual versatility and enormous influence in the world of science, affect the course of this subject beyond writing an introduction to the German translation of Ingen-Housz's work. The writings of Schleiden and of Liebig certainly did much to improve the conceptions of nutritional science of the day, but their efforts were entirely critical and not experimental, hence no real contributions resulted from their efforts; while such men as Mohl, Nageli, Hofmeister and Darwin were also following other lines of thought. The experiments of Bousingault do stand out clearly at this period. He finally demonstrated with his method of water culture the true source of carbon for the plant, as well as the fact that atmospheric nitrogen is not directly taken up by the plant.

Sachs through his studies of chlorophyll function awoke new interest in the subject. His work on the formation of starch, as well as that of Böhm on the effect of sugars on starch formation, has led to an extended elaboration of this phase of the subject. And finally Wm. Draper of New York conducted extensive investigations on the effect of different portions of the spectrum on the evolution of oxygen, the results of whose work have been verified and extended by the studies of Pfeffer. Most of the botanical contributions of the last thirty years have been largely confined to detailed studies along the courses outlined by these workers. It is not detracting from their value to say that

no new vistas have been opened nor original hypotheses formulated.

During the period just reviewed, all branches of science experienced development and revolution beyond all precedent in the history of thought. A discovery in one domain of science often exerted great influence over its allied or even distantly related sciences. We need but recall how the Newtonian gravitation formula affected not only astronomy and physics, but chemistry and physiology. During this time such fundamental conceptions as the conservation of energy, the undulatory theory of light, spectrum analysis, entropy and the primary laws of photochemical action were formulated, all of the most direct importance to the problem of photosynthesis. These great discoveries have even now found little application to our subject.

The most important aspect of the problem of photosynthesis is probably the energy relation. By virtue of this photochemical action we are kept alive, we derive all of our food, we keep warm, travel, and run our industries, by the use of fossil energy, coal. It is this question of energetics which in spite of some of the excellent attempts which have been made, has hardly been touched, and lies at the very center of the problem at least from a humanitarian viewpoint. As Boltzman pointed out in his classical paper on the second law of thermodynamics, the struggle for existence is essentially not a fight for the raw materials, which are abundant in earth, sky and sea, nor for the energies as such, but for the potential energies as in coal, sugar and meat.

It would seem that the plant itself is not very efficient in the utilization of this energy, and certainly our methods of determining the values have been anything but satisfactory. This is largely due to the number of variable factors entering into the experiment and calculation. The determinations of Puriewitsch may serve as a good example. The light was measured by means of a bolometer, and the amount of photosynthate or material synthesized was determined by the half-leaf method. The energy of this material was determined from the heat of combustion.

	Before Isolation	After Isolation
Area of half leaf	316.6 sq. cm.	316.8
Dry weight of half leaf	1.2494 g.	1.3952
Dry weight per sq. cm.	0.0039	0.0044
Heat of combustion of 1 g. dry weight	4300.21 g. cal.	4313.46 g. cal.
Heat of combustion per sq. cm.	16.770	18.978
Increase of heat of combustion after insolation per sq. cm.	2.208 g. cal.	
Total energy fall on leaf	361.03 g. cal.	
Energy used in assimilation	0.6 per cent.	

The values for the energy utilized vary greatly, from 0.6 per cent. to 5.0 per cent. with the same and different kinds of plants. One of the great difficulties has been that we do not yet know with what sort of system we are dealing. It is quite clear that it is not one simple chemical reaction, but a series into which various factors enter, and in some of which light plays the leading rôle. So that as the results indicate, these values are the merest approximations. In fact, the old question how does light act in effecting the reduction of carbon dioxid and water, seems almost as far from solution as ever. It is still an open question whether we are dealing with a so-called photo-catalytic action in which light only accelerates an irreversible process, in which case we cannot regard the energy of light as being stored in the transformed substance, or whether it is a true photochemical action. One great difficulty here has been that the physicists themselves have not been unanimous in accepting the theoretical principles of radiant energy and its relation to chemical action.

Recent conceptions of the nature of light and of chemical forces ought to find application to the processes involved in photosynthesis. It seems highly probable that the forces of chemical affinity are electrical in character, and matter may be regarded as a complex structure of small particles, the atoms, together with very much smaller particles called electrons. The number of electrons which accompany an atom to a large measure determine its chemical properties; valency under this conception depends upon the relative ability of the atoms to eject or attract electrons, and the chemical effects produced by light are due to the emission of electrons from some of the atoms of the illuminated substance. Each electron always has a negative charge of electricity and is therefore attracted towards all positive charges. Under certain conditions some substances lose electrons and acquire a positive charge. Thus there are a number of metals which when exposed to the rays of ultra-violet light take on a positive charge, and this has been traced to the emission of the negative electrons from the illuminated surface. The phenomenon is known as the photoelectric effect, and has been observed in a large number of substances, including a variety of dyes. There is considerable evidence for believing that the valency electrons which are the chemical bonds in molecules, are identical with the photoelectric electrons which can be liberated by the action of light. From this point of view, a photochemical change and a photoelectric change are of the same character, consisting primarily in the loss or displacement of an electron through the absorption of energy from a light

wave. It is not possible here to enter upon a discussion of the photochemical laws, but it seems quite certain that the first stage in any photochemical reaction consists essentially in either the partial or complete separation of negative electrons which are either emitted or attach themselves to other chemical groups or atoms. There takes place thus a rearrangement of the energy distribution in the system which, of course, involves chemical changes.

The phenomena of oxidation and reduction may be interpreted upon the same basis. Thus, for example, the oxidation of ferrous sulphate with bromine water may be represented:

$$2\overset{++}{Fe} + 2\overset{--}{SO_4} + \overset{+}{Br_2} \rightarrow 2\overset{+++}{Fe} + 2\overset{--}{SO_4} + 2Br.$$

The ferrous salt is "oxidized" to a ferric salt and the bromine "reduced" to a bromine ion. It will be noticed that the "oxidation" (I purposely retain the old terminology) involves the passage of a positive charge to the ferrous ion, the bromine being the oxidizing agent, or the ferrous salt the reducing agent. There cannot be oxidation without corresponding reduction, and reduction consists essentially in the loss of a negative charge. Oxygen acts as an oxidizing agent because it has a great tendency to take away a negative charge from other substances and go over into electronegative oxygen of a compound, usually water. In photosynthesis the process is quite the reverse. If we assume that the action is empirically:

$$XCO_2 + XH_2O \rightarrow (CH_2O)_x + XO_2,$$

water is oxidized and CO_2 is reduced presumably to carbohydrates and the negative charges are taken up by the carbon compounds. Thus photosynthesis must be accompanied by decided electrical disturbances and of a nature which are in a sense the reverse of those taking place in the oxidation of food material. This furnishes us with a point of attack and possible basis for the explanation of the electrical disturbances characteristic of living things. As yet no application has been made of these principles, though it is noteworthy that the atmosphere surrounding a leaf is ionized and Waller has described certain electrical disturbances in the leaf. These are apparently associated with the photosynthetic activity, for the action ceases on the removal of CO_2, and is not brought about by light which has been filtered through a green leaf.

McClelland and Fitzgerald have recently observed that

green leaves in the light of an aluminium arc exhibit a decided photoelectric discharge, as do also aqueous solutions of chlorophyll. I have tried to detect such an effect by the use of sunlight, but have never succeeded. It would seem that the electrons are emitted only under special conditions, and ordinarily are probably attached to the escaping oxygen or water vapor.

The application of physical conceptions and methods of experimentation as yet have not been applied to the study of photosynthesis with any high degree of success in penetrating to a clearer view of the process. This to a large measure has been due to the fact that our knowledge of the chemistry of the process has been so very fragmentary. The physical investigations have indicated that the process is apparently not a simple one, but dependent upon a number of variable factors. Physics employs essentially quantitative or mathematical forms of expression. But before quantitative terms can find expression, it is essential that at least a certain amount of qualitative knowledge is existent. We must know, at least, whether a proposition is affirmative or negative; some elements of the hypothesis must be established. Thus it was possible for de Saussure to apply quantitative methods to the discoveries of Ingen-Housz and Sénébier, but our qualitative knowledge has not progressed much beyond the discoveries of these men. Sachs elaborated the observations of Mohl on the starch grains and thereby introduced the subject of sugar chemistry into the process. It became then distinctly a chemical problem.

The course which the development of chemistry took was influenced by a number of factors. It is evident that science has progressed essentially by the efforts of a relatively few individual thinkers who set the minds of many working in certain directions, and that science, like social and political institutions, is not above the influence of fashions which have been followed by the majority, and often not altogether to the advantage of the broad development of knowledge. At the time of Liebig organic chemistry was devoted to the study of the chemistry of living things. But with the discovery of the constantly increasing number of carbon compounds and under the leadership of men like Victor Meyer, Kekulé, Hofmann and Baeyer, the primary interest was shifted to theoretical considerations of constitution and structure. Combined with this, the effect of the lure of the commercial application of synthetic products and the development of new processes, forced the study of chemistry of the phenomena of nature into second place. Physiological chemistry with relatively few disciples was de-

voted largely to animal investigation. And it is only within rather recent times that there has been a return to what might be termed general physiological chemistry with the plant studies in the decided minority.

Probably as a result of this state of affairs on the educational system, the contributions of the chemists to the problem of photosynthesis have not been of the thorough and profound nature which the subject demands. Most of the suggestions of the chemists concerning the course of the process have been purely hypothetical and speculative, exhibiting the most lamentable ignorance of the fundamental character of the process, and often with total disregard of the structure of the chlorophyllous cell and the properties of living matter. It is not surprising, therefore, that many botanists paid little attention to these efforts and few cooperative efforts were undertaken.

From the chemical viewpoint, the salient fact regarding the process of photosynthesis is that carbohydrates are the first products which accumulate in sufficient quantity for detection. It is by no means established in what manner these substances are formed, but as the formation of sugars has been found to accompany the process almost universally and the course of accumulation has been extensively studied, they have come to be regarded as the first visible products. The sugars then stand in the very center of the food economy of plants.

Before discussing the subject of the sugars themselves let us consider very briefly the manner in which these are supposed to be formed in the chlorophyllous cell. This portion of the problem has not advanced beyond the purely hypothetical stage, although it is very frequently treated as though the principle had been firmly established. The theory which has received the greatest recognition, and, it would seem, almost universal acceptance, is the formaldehyde theory. This hypothesis was formulated by Baeyer as a mere suggestion. During the fifty years since its appearance, this suggestion has become almost an axiom. It might be desirable, therefore, to examine briefly the evidence upon which this theory rests in order to determine whether its widespread acceptance is warranted by experimental proof.

In 1861 Butlerow had discovered that formaldehyde, in aqueous alkaline solution, condenses to an optically inactive syrup, possessing some of the properties of hexose sugars. Baeyer considered formaldehyde in aqueous solution to be $CH_2(OH)_2$, and the Butlerow condensation as simply one of water loss and condensation of six $CH_2(OH)_2$ molecules.

$$6CH_2(OH)_2 - 6H_2O \rightarrow COH \cdot (C(OH)H)4 \cdot CH_2OH.$$

Baeyer then suggested that this may be the way in which grape sugar is formed in the plant. The idea of the similarity of chlorophyll and hemoglobin was prevalent at the time; it seemed, therefore, likely that chlorophyll should also fix CO. The sunlight splits the CO_2 into CO and O, the oxygen escapes, and the carbon monoxide, held by the chlorophyll, is reduced to formaldehyde, $CO + H_2 \rightarrow COH_2$, which is then condensed to sugar. This is the substance of the Baeyer hypothesis, formulated without the support of experimental evidence. It was proposed as a possibility and received no further attention in the writings of its founder.

The fact which more than any other gave strength to this theory, and which is the underlying principle of the whole idea, was the discovery of Butlerow. This discovery was elaborated by O. Loew, who gave the name formose to the sugar mixture, and especially by Emil Fischer, who prepared therefrom some of the sugars found in nature.

The hypothesis has to a great extent directed the course of investigation of the chemical aspect of photosynthesis. The experiments have followed three different lines of argument:

(1) The reduction of carbon dioxid to formaldehyde by various chemical and photochemical means. (2) The detection of formaldehyde in illuminated green leaves. (3) The feeding of plants with formaldehyde as the only source of carbon.

All of these have yielded direct positive results, although it is impossible to give a description of the very numerous experiments. The main points at issue are, however, whether we are justified in applying the results of experiments carried out *in vitro* or under other abnormal conditions, to the living plant, and whether the conditions in the experiments simulate sufficiently those existent in the chlorophyllous cell to permit of valid deductions. In spite of the very numerous contributions which have been made to this special subject, a critical study of all the facts leads to the conclusion that it will require a great deal more experimental substantiation before this theory can serve as the basis for an explanation of the mode of sugar manufacture in the leaf.

Although Sachs had identified the formation of starch in the chloroplasts with the photosynthetic activity, it was later recognized by Meyer that many leaves never form starch. In the latter case there is an accumulation of cane sugar. Boehm then found that in either kind of leaf there was an accumulation of starch or sugar when the leaves were placed on solutions of glucose or fructose. The question has then naturally arisen as to

what is the first sugar formed in photosynthesis. This is, of course, an immensely important problem, as its solution would throw much light on the chemics of the photosynthetic process. As yet no definite solution has been gained, and the results are by no means concordant. The conclusions have been drawn largely from a consideration of the variation in amount of different sugars and from microchemical tests. The latter can not be considered sufficiently accurate to differentiate positively between various sugars. The following are the results of Brown and Morris with the garden Nasturtium, and serve as the best illustration. The values represent percentages of the dry weight.

Carbohydrate	Picked and Dried 5 A. M.	Picked 5 A. M. Kept Insolated in Water Until 5 P. M.	Picked and Dried 5 A. M.
Starch	1.23	3.91	4.59
Sucrose	4.65	8.85	3.86
Glucose	0.97	1.20	0.00
Fructose	2.99	6.44	0.39
Maltose	1.18	0.69	5.33
Total sugar	9.69	17.18	9.58

Carbohydrate	Picked and Dried at Once	Leaves Kept in Water in Dark for 24 Hours After Picking
Starch	3.69	2.98
Sucrose	9.98	3.49
Glucose	0.00	0.58
Fructose	1.41	3.46
Maltose	2.25	1.86
Total sugars	13.64	9.39

From these results Brown and Morris conclude that cane sugar is the first sugar formed in the leaf, and that it is a temporary reserve material which accumulates during active photosynthesis. When the cane sugar reaches a certain concentration, an excess is converted into starch. Prior to translocation, the cane sugar is inverted into glucose and fructose. The fact that leaves which are photosynthetically active all day contain no glucose or fructose is used by Brown and Morris as an argument that these can not be the first sugars formed. In the cut leaf insolated in water, translocation has presumably been stopped, and they point out that cane sugar and starch both increase greatly, but glucose very little. Fructose, the other hexose, it should be noted, however, increases decidedly.

One factor which has been overlooked in these considerations is the transformation of the various groups of sugars quite independent of the process of photosynthesis. This mutual

transformation is of the nature of a complex equilibrium with the monosaccharides as one extreme, and starch as the other, controlled, in all probability, by enzyme action. This equilibrium is affected by various influences, more particularly by the water content of the system and temperature. It is evident then that the amount, or proportion to the total of certain sugars present in the leaf after insolation, can not be taken as an indication of the rate at which these sugars are formed in the photosynthetic process, for under varying conditions of water content and temperature, such as occur in a leaf in the sunlight, there is a consequent shifting of the carbohydrate equilibrium, resulting in the accumulation of one or the removal of another group of sugars according to circumstances. Therefore, in a study of the first sugar formed in photosynthesis, these conditions (water content and temperature) either must be kept constant or, what is more feasible, the equilibrium under the particular circumstances must be established before any conclusions can be drawn as to the immediate source of any particular sugar.

The fleshy joints of some of the cacti have offered splendid material for studies of transformation of the sugars. These plants are capable of large variation in their water content, the joints can be removed from the plants and subjected to a variety of conditions without injury. Thus two sets of joints were kept at different temperatures in the dark for twenty days and then analyzed. The values are percentages of the dry material.

	28° C.	10-15° C.
Dry weight	33.0	33.6
Total sugars	5.72	6.21
Total polysaccharides	5.28	5.59
Hexoses and disaccarides	0.40	0.60
Total hexose sugars	2.17	2.38
Disaccharides	0.26	0.32
Hexoses	0.16	0.27
$\frac{\text{Total polysaccharides}}{\text{Total sugars}}$	.913	.900
$\frac{\text{Hexoses}}{\text{Hexose polysaccharides}}$	.0884	.147
$\frac{\text{Hexoses and disaccharides}}{\text{Total sugars}}$	.069	.0966

It is evident then that in general a low temperature tends to shift the equilibrium in the direction of the simpler sugars.

Similar relations hold for the effect of the water content. The table below gives the results of two sets of joints, one set (A) kept dry, the other (B) given water:

	A	B
Dry weight	22.80	17.70
Total sugars	18.84	18.58
Total polysaccharides	16.21	15.77
Hexoses and disaccharides	.56	.81
Total hesose sugars	8.43	7.81
Disaccharides	.30	.36
Hexoses	.26	.45
$\frac{\text{Total polysaccharides}}{\text{Total sugars}}$	.861	.849
$\frac{\text{Hexose}}{\text{Hexose polysaccharides}}$	.032	.063
$\frac{\text{Hexoses and disaccharides}}{\text{Total sugars}}$	.0297	.0436

Thus the water content of a leaf decidedly affects the nature of the sugars, and in such a manner that decreasing water content shifts the equilibrium in the direction of the more complex or more condensed sugars, while ample water brings about inversion or the formation of the simpler sugars. In the pentose series the action is of the same nature. It is a noteworthy fact that the water content does not seem to affect the rate of respiration as measured by CO_2 evolution.

Unfortunately in the results of Brown and Morris and the other workers who have investigated the problem of the first sugar, not sufficient data are given regarding leaf temperatures and water content. These factors when considered in the light of the results just given would materially affect the interpretation of the analyses.

The examples given here illustrate to some degree the complexity of the problem of photosynthesis. The enormous importance of this phenomenon to human welfare needs no elaboration. Progress undoubtedly lies in the fortunate cooperation and application of the methods and concepts of various branches of science; botany, physiology, chemistry and physics. The dangers lie in the over-application of physical and chemical theories based on restricted observation and acquaintance with the phenomenon itself.

MAN AND HIS NERVOUS SYSTEM IN THE WAR

BEING SOME REFLECTIONS UPON THE RELATION OF AN ORGANISM TO ITS ENVIRONMENT

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ADMIRAL SIR JOHN JELLICOE, in the dark months of the past year, advised his countrymen to look at a map, and, furthermore, to look at a large map if they wished to get a true perspective of the war. I would like to present a picture for inspection, and, furthermore, I would like to present a large picture, as I believe that in a large picture we may find comfort. In a large picture, some of the lines may be blurred and indistinct when examined microscopically, but the perspective is better. And when once we get a perspective, we may elaborate detailed portions of the picture to the limit of microscopic vision. The picture, to be sure, is, in part, drawn after the events have occurred, and to this extent now represents afterthought rather than forethought. But if I mistake not, some of the conditions which have given rise to trouble in the past will greatly outlast the war, and a recognition of the sources of evil in the past may help us in avoiding, or in coping with, the sources of evil in the future. Assuredly, man's mind is in need of comfort, and while one does not ordinarily look to the biologist for comfort in times of adversity or trial, I hope to be more successful than the officious gentlemen who called on Job.

Some, like Mr. Britling's son Hugh, have tired of the war at times and wished for stories of gods and heroes so that they might forget for the moment the horrors of the conflict. I have at times been one of them. But not until the news of the signing of the armistice arrived was I able to sit down and read with untroubled mind anything that did not have some more or less close connection with the war and the part which I was trying to fulfil in it. For those who may have felt as I did at times, but who still look forward with some anxiety to the formulation of the peace terms and the statement of the means adopted for curbing some of the vanities of human ambition for the future, I wish to show that the study of the effect of war and war conditions upon man is a biological study of the effects of

the environment upon organisms and that if the essential relations of biology to the life of man had been fully recognized this war might not have come. I wish to present a statement that I have worked out in my own mind in the terms of my chosen science, physiology. To be sure we are dealing with one species of organisms and not with organisms in general; and the environment bears the trade mark, "Made in Germany." But biology is essentially an inductive science, or group of closely related sciences, rather than a deductive science, and inferences drawn from a study of one group of organisms will fit somewhere in the general scheme of inductive thought when it is finally worked out. I will first map out the general field of physiology as it has been developed up to the present, and then show how the information now available may be applied to some of the problems of the war.

The Progress in Physiology in the Past Century

The Place of Physiology in Scientific Thought.—For the benefit of those who may vaguely wonder, as some of my friends have wondered at times, what physiology has to offer to general biological thought or to scientific thought as a whole, a brief statement of the progress of physiology during the past century may not be out of place. Merz[1] speaks of the conflict early in the past century between vitalism and the mechanistic conception of life processes as one of the fundamental phases in the development of physiology, and attributes a large share in the founding of physiology on the mechanistic basis to Johannes Müller. Merz quotes Emil Du Bois Reymond[2] as follows:

> The modern physiological school with Schwann at its head, has drawn the conclusions for which Müller had furnished the premises. It has herein been essentially aided by three achievements which Müller witnessed at an age when deeply-seated convictions are not easily abandoned. I mean first of all, Schleiden and Schwann's discovery, that bodies of both animals and plants are composed of structures which develop independently, though according to a common principle. This conception dispelled from the region of plant-life the idea of a governing entelechy, as Müller conceived it, and pointed from afar to the possibility of an explanation of these processes by means of the general properties of matter. I refer, secondly, to the more intimate knowledge of the action of nerves and muscles which began with Schwann's researches, in which he showed how the force of the muscle changes with its contraction. Investigations which were carried on with all the resources of modern physics regarding the phenomena of animal movements, gradually substituted for the mir-

[1] "A History of Thought in Europe during the Nineteenth Century," I., p. 217, Edinburgh and London, 1903.

[2] Reden, Vol. II., p. 219.

acles of the "vital forces" a molecular mechanism complicated, indeed, and likely to baffle our efforts for a long time to come, but intelligible, nevertheless as a mechanism. The third achievement to which I refer is the revival among us by Helmholtz and Mayer of the doctrine of the conservation of force. This cleared up the conception of force in general, and in particular supplied the key to a knowledge of the change of matter in plants and animals. By this an insight was gained into the truth that the power with which we move our limbs (as George Stephenson did those of his locomotive) is nothing more than sunlight transformed in the organism of the plant: that the highly oxygenated excrements of the animal organism produce this force during their combustion, and along with it the animal warmth, the "pneuma" of the ancients. In the daylight which through such knowledge penetrated into the chemical mechanisms of plants and animals, the pale spectre of a vital force could no more be seen. Liebig, indeed, who himself stood up so firmly for the chemical origin of animal heat and motive power, still retains an accompanying vital force. But this contradiction is probably to be traced to the circumstance that the celebrated chemist came late, and as it were from the outside, to the study of the phenomena of life. And even Wöhler still believes in a vital force, he who in his time did more than any one to disturb the vitalistic hypothesis through his artificial production of urea.

Merz later admits that the French physiologist Vicq-d'Azyr, who, by the way, was a professor in the Ecole veterinaire d'Alfort and a neuro-anatomist of considerable ability, had, earlier than Johannes Müller, clearly stated the mechanistic conception of life processes. Merz[3] quotes from Du Bois Reymond[4] this extract from Vicq-d'Azyr:

Quelqu' étonnantes qu'elles nous paraissent, ces fonctions (viz., dans les corps organisés) ne sont-elles pas des effets physiques plus ou moins composés dont nous devons examiner la nature par tous les moyens que nous fournissent l'observation et l'expérience, et non leur supposer des principes sur lesquels l'esprit se repose, et croit avoir tout fait lorsqu'il lui reste tout à faire.

One may remark in passing that, despite his recognition of the relation of the cell theory to the Aristotelio-Drieschian conception of an entelechy, Johannes Müller[5] still remained much of a vitalist. So deeply was the vitalistc theory ingrained in

[3] *Ibid.*, p. 219.

[4] Reden, Vol. II., p. 27.

[5] Although he himself (Müller) is truly regarded as the last of the vitalists—for he was a vitalist to the last—his successors were adherents of what has been very inadequately designated the mechanistic view of the phenomena of life. Burdon-Sanderson, J. S., *Nature*, 1893, XLVIII, p. 466.

Even after the discovery by Wöhler in 1828 of the possibility of producing synthetically such an organic substance as urea, such a universal mind as that of Johannes Müller was still clinging to the belief in the all-powerful force as the creator and harmonizer of the various mechanisms of the living body." Meltzer, S. J., *Science*, 1904, N. S., XIX., p. 18.

the minds of physiologists and others that Du Bois Reymond years afterward remarked that behind such terms as cell autonomy there lay concealed the thinly veiled specter of vitalism.

Merz's statement may appear insufficient to the physiologist, but I am merely quoting it to show just what impression physiology as a whole has made on the mind of a keen and diligent student of scientific thought in the nineteenth century. Compared with his statement on morphology, it is meager enough. One unfamiliar with the great names in physiology, and who did not look through the index for them would truly get an inadequate idea of the influence of physiology upon thought in the past century. Nor do the references to the physiological units of Herbert Spencer or to "physiological division of labor" really carry us much further into the place of physiology in scientific thought. For Milne-Edwards was an anatomist and comparative physiologist, and Herbert Spencer a philosopher. Their conceptions of processes or properties, however valuable they may have become in biological thought, can scarcely be claimed as the property of the workers in the technical laboratories of physiology. Howell[6] epitomized the situation by saying: "We must perhaps admit that the philosophical basis of physiology, its general principles and quantitative laws, have been borrowed in large part from other departments, and that the subject has not as yet fully repaid this indebtedness by contributions derived solely from its own resources." Nor does one find much mention of the relation of physiology to the other biological sciences in Verworn's article "Physiology" in the Encyclopædia Britannica. But if, as is generally alleged, physiology is one of the biological sciences, it must have some elements in common with them and hence some relation to the great questions of biology. It would seem permissible, therefore, to add something more on the place of physiology in scientific thought. We may first review briefly the progress of physiology, in order to get a background of fact upon which to base our conclusions, and then search particularly for those phases of the work which may serve to connect physiology with the great problems of biology in general. Those who are especially interested in the development of physiology should read also Professor Howell's address and those by Professor Burdon-Sanderson and Dr. Meltzer to which I have just referred. As will become apparent from what follows, the particular field of physiology has been the study of the individual and its internal conditions.

[6] "Problems of Physiology of the Present Time." Congress of Arts and Science, Universal Exposition, St. Louis, 1904, Vol. V., p. 1.

The Study of the Internal Organization of the Living Organism

The work in physiology during the past century, and one should add twenty-five years to cover the beginnings in the eighteenth century and the continuation in the twentieth, has been along the lines of the chemical organization and a nervous organization. I will not enter here into a discussion of the moot question whether the nervous mechanism may not be at bottom a chemical mechanism. Assuredly, the nervous mechanism has some chemical properties, but the methods of investigation of the two systems are at present sufficiently different in character to warrant us in retaining the term nervous organization for a time at least. While investigation of the two systems of organization has proceeded more or less together, the development of the knowledge of each may be considered separately. Other writers might not choose the same facts or the same names that I have chosen, but I have taken those things which seem adapted for bringing out the particular points I wish to emphasize.

The Chemical Organization of the Body

Lavoisier, toward the close of the eighteenth century, showed that the heat production by an animal in a given time was directly proportional to the amount of carbon dioxide produced in the same time. This result led to the discussion of the nature of the chemical processes in living matter. It was generally admitted that the production of heat in animals was the result of a process of slow combustion, and the idea of a catalytic agent and of catalytic reactions soon followed. We have come to recognize more and more clearly that many of the chemical reactions occurring in living matter are of the same general nature as the "slow" reactions of the laboratory of physical chemistry.[7]

The line of investigation started by Lavoisier had other results. His original experiment in animal calorimetry was repeated with greatly improved methods by Regnault and Rieset, Pettenkoffer and Voigt, Atwater and Benedict and others, until the original discrepancy of a few per cent. between Lavoisier's observed results and the calculated results has been reduced to a few tenths of one per cent. From these experiments, and van Helmont's earlier experiment[8] on the increase in weight of a tree, the modern study of metabolism has arisen. Biologists generally regard metabolism as one of the funda-

[7] Blackman, F. F., *Nature*, 1908, LXXVIII., p. 556.

[8] Foster, "Lectures on the History of Physiology," 1901, p. 133.

mental properties of living matter. Goodrich's statement[9] in 1912:

> The metabolic process in living matter draws in inorganic substance and force at one end, and parts with it at the other; it is inconceivable that these should, as it were, pass outside the boundaries of the physico-chemical world, out of range of the so-called physico-chemical laws, at one point to reenter them at another,

is a sufficiently close restatement of Vicq-d'Azyr's conclusion of more than a century before to justify the correctness of his physiological vision. That we do not yet know all the transformations of inorganic substance and force in the metabolic process is true. But to say that such transformations are not physico-chemical processes, as I have heard it said at various times, involves a peculiar mental operation which I am at a loss to understand. One might as well say that, because we can not explain the transmission of electricity along a wire—and I am not aware of any such explanation at present which is complete and wholly free from objection—such transmission is not a physico-chemical process. If vitalistic properties enter into metabolism at all, they can not consume more than a few tenths of one per cent. of the total energy involved in the process. To the other virtues of vitalism which Du Bois Reymond mentioned in his own humorous way, we must, therefore, add extreme economy of operation.

The artificial synthesis of many of the products at one time supposed to occur in living matter only, beginning with Wöhler's synthesis of urea in 1828, and extending through a long series of carbohydrates and even of polypeptids, is another series of achievements along the line of the chemical organization of the organism. Through the chemical study of the nature of the various compounds occurring in living matter, we have been able to extend our knowledge of the processes of metabolism in general, and of nutrition in particular.

The doctrine of the conservation of energy led to a new discussion of the position of life. Balfour Stewart[10] compares living matter to the class of machines whose distinguishing characteristic is their incalculability. He mentions also that "Joule, Carpenter and Mayer were at an early period aware of the restrictions under which animals were placed by the laws of energy, and in virtue of which the power of an animal, as far as energy is concerned, is not creative but directive."

Physiologists generally have considered this characteristic

[9] "The Evolution of Living Organisms," London and New York, p. 15.

[10] "The Conservation of Energy," New York, 1874, Chapter VI.

of incalculability in living matter under the head of irritability, and it has been recognized by biologists generally as one of the essential characteristics of living matter. It must be considered in any discussion of the internal organization of living organisms. Much misty terminology and vagueness of expression has clung about it, and the conception of irritability as Pfeffer formulated it has much of the element of vitalism in it. Blackman has expressed the hope that some of the implications of irritability will disappear from biology, and be superseded by a more modern statement in terms of chemical mechanics. As attention has been more and more focused upon it, the incalculability of deportment of living matter has been found to be little or no greater than that of high explosives in government storehouses, and one would have some hesitancy in attributing vital characteristics to explosives under recent diplomatic conditions. The term stimulus so often used in connection with irritability is another instance of a word which has no very definite meaning except a rather arbitrary one. It is my belief that the laws of chemical equilibrium are applicable, and will do much to clear up our idea on the subject. If, as there is now every reason to suppose is the case, the reactions in living matter are like other physico-chemical reactions, stimuli, which influence the reactions in living matter, are comparable to the conditions which influence ordinary physico-chemical reactions.

A discovery of considerable importance, as illustrating the action of a number of chemical substances in the body, was made by Bayliss and Starling in connection with the mechanism of eliciting secretion of the pancreas. These investigators found that when the acid contents of the stomach come into contact with the mucous membrane of the duodenum, a substance called secretin is formed in the mucous membrane. This substance secretin is absorbed by the blood and carried through the circulatory system to the pancreas where it excites the cells in such a way as to produce a secretion. Substances which, like secretin, are formed in one place and carried in the fluids of the body to another, there to elicit a response, are known as hormones or chemical messengers.

There have been other phases of work along the line of the chemical organization of organisms which would require too much space for a detailed consideration. One which seems to me significant is the determination of the various forms of starch grains and hemoglobin crystals by Reichert and Brown. These results tend to show that each species has its own peculiar physico-chemical constitution, that each organism has, in fact, a physico-chemical system of its own.

This work on the crystallography of the hemoglobins is an extension along another line of the work of Kossel on the chemical constitution of the protein molecule. According to Kossel, this consists of groups of aminoacids tied together, the nature of the acids and the number of each kind in the protein molecule depending upon the sort of protein selected for analysis. To a certain extent, the food value of any protein in animal nutrition depends upon the closeness of approximation of its qualitative and quantitative content of aminoacids to that of the tissues of the animal by which it is used for food.

Blackman, *loc. cit.*, in a most suggestive paper, has considered the chemical organization of the plant from the point of view of the application of the principles of chemical mechanics to the processes in living organisms. In the ten years that have elapsed since the publication of Blackman's address, the field of the application of the principles of chemical mechanics to the processes in living matter in general has been considerably extended.

It may be objected that we have never shown that the same principles cover the deportment of living and non-living matter, and the objection must be allowed. But neither do we know what principles cover the deportment of non-living matter in its entirety. Until we have gone farther in both fields, we have no rational basis for saying that living matter demands peculiar principles of its own. When it has been definitely shown that the principles of chemical mechanics, as they have been built up from the study of non-living matter, do not apply to living matter, or that no future principles which may be built up from the study of non-living matter will apply to living matter, we may be forced to take refuge in vitalism. But for the present, the free use of that old canon of logic known as William of Occam's razor[11]—the principle that the unnecessary supposition that things of a peculiar kind exist when the facts may be equally well explained on the supposition that no such things exist is unwarranted—should be freely applied in this connection.

But the chemical organization of the body, as has been stated, comprises but a part of the internal organization of the animal. We may now proceed to the consideration of the other phase, the nervous organization of the animal body.

The Nervous Mechanisms of Animals

The work on the nervous organization of the animal body has been done mostly on vertebrates, frogs, birds and mammals

[11] Entia non sunt multiplicandum praeter necessitatem. (Article "Razor," Century Dictionary.)

being chiefly used for experiment. Anatomical and pathological study has included the human nervous system as well. The influence of the Italian anatomist Rolando is reflected in the Rolandic area of the cerebral hemispheres, a term that still persists.

The French physiologists of the early part of the last century—Magendie, Le Gallois, Lorry, Desmoulins, Flourens and others—began or continued fundamental work on the organization of the central nervous system. Magendie published his text on physiology in 1816. So well were the chapters on the nervous system done that the Italian physiologist Luciani in 1893 wrote that he still found it a valuable and useful book. I can make the same statement in 1918. Magendie recognized the rôle of the central nervous system, not only in movement, but also in the maintenance of the attitudes of the body. He also stated that the division of the brain into its anatomical levels or segments such as cerebrum, cerebellum and the like was a purely artificial division so far as its physiology was concerned. In 1916 Luciani found occasion to emphasize the functional unity of the brain. Magendie also gave a statement of the mechanism of instincts which is so clear that I still regard it as one of our best.

Later in the century the discoveries in microscopy gave us definite ideas of the cellular structure of the nervous system. The accidental discovery of the Italian anatomist Golgi gave us a method of coating a nerve cell and all its processes with silver and enabled us to see clearly for the first time their exact form and extent. Anatomical and pathological studies have given us some knowledge of the relations of the fiber tracts in the brain and spinal cord. The anatomical phase of the subject is not yet complete and will not be for years to come.

The clinical observations of Broca on disorders of speech and of Hughlings Jackson on epileptic convulsions led to the early ideas of cerebral localization. The experimental results of Fritsch and Hitzig demonstrated that motor nerve fibers, excitation of which led to movements of particular groups of muscles, originated in definite regions of the cerebral cortex. Subsequent observations have shown that sensory fibers from particular sense organs have definitely localized end stations in particular regions of the cerebral cortex. There are still many unsettled questions in the field of cerebral localization, and much difference of opinion as to the degree or extent to which various functions rest upon an anatomically circumscribed basis in the cerebrum. Some would go so far as to deny

cerebral localization in some of its essential aspects. Personally, however, I regard the theory of cerebral localization, and of localization in general within the nervous system, as well established in its main outlines.

The idea of functional integration, or physiological integration, as Herbert Spencer called it, has an application in the nervous organization as well as in the chemical organization of the organism. On its nervous side, it has been developed by Sherrington as the integrative action of the nervous system. Aristotle remarked that there was nothing in the mind, except what had come in through the senses. This conception can, I believe, be carried over to the side of the motor responses as well as to the mental. There are conditions, apparently, under which motor cells may discharge impulses without the previous access to them of afferent impulses over fibers of other nerve cells; but it does not appear to be the normal biological procedure. Afferent impulses seem necessary for the proper control of motor responses, or, to paraphrase a statement of Edinger, afferent impulses seem necessary to make the motor responses biologically adequate. The afferent impulses must be summed up or integrated somewhere within the central system before a biologically adequate motor response can occur.

The ordinary motor response to afferent impulses may be called a reflex response. The essential condition is that an afferent impulse shall find its way into the central nervous system and thence be "reflected back" over a motor pathway to a muscle or gland at the periphery. In recent years, Pawloff has shown that a sound of a given pitch or a particular color, or other external agent which, by itself, will not bring about a reflex secretion of the salivary glands of a dog, may be sufficient to excite such a reflex secretion if employed for a time every day in association with the same external agent which will normally bring about a reflex of saliva. If, for instance, a dog is shown a square of blue paper every day at the same time it is shown food, which will by itself elicit a reflex flow of saliva, after the lapse of a few weeks, the sight of the blue paper alone is sufficient to elicit the reflex flow of saliva. Pawloff has applied the term "conditioned reflexes" to such responses. From my own experimental results and from data now in the literature, I have concluded that practically all reflexes are conditioned reflexes, since, as I see the problem, a definite group of afferent impulses from different peripheral sources is necessary if any reflex response is to be biologically adequate. A certain definite set of conditions is necessary, therefore, for the elicitation of a

definite reflex response. As may be gathered from these statements, I am inclined to extend the term reflexes to include a considerably larger group of phenomena than is covered by the older definition. On this point, I would sustain Loeb in his use of the term reflex in its wider meaning.

Beyond a certain point, the application of the general principles of chemical mechanics to the problems of the physiology of the central nervous system does not now seem possible. There has been, it is true, some change in the chemical composition of the nerves in the transition from frog to man. Certain protein substances which are coagulable at a temperature of 36° C. to 40° C.—a temperature below the ordinary body temperature of birds—appearing in the nerves of the frog are absent from the nerves of mammals and birds. But, in general terms, the same chemical foundation—the proteins as a group—is present, so far as we now know, in all nervous systems of vertebrates. Various other substances of a fatty nature, but all containing phosphorus or sulphur are also present in unmedullated nerve fibers, but we do not know either the exact nature of these substances in the nervous systems of various animal forms, nor how their variation affects the function of the nervous system at various levels in the evolutionary scale. The study of the metabolism of nerve cells and fibers is a chemical problem, and, to this extent, there is a chemical phase in the study of the nervous mechanism of the animal body. This chemical phase extends also to the study of disease in the nervous system, and through the work of Thudicum, Mott, Halliburton, Koch and others we have the beginnings of what we may hope will be an important phase of the study of the organization of the nervous system.

The study of the nature of the nerve impulse is also a chemical or a physical problem, or as now seems likely, a combination of the two.

The particular thing which characterizes the nervous system as a system is not its chemical organization, nor its rôle as a chemical mechanism, but its action as a coordinating or integrating mechanism. It is this integrative action which Sherrington has so luminously set forth in his writings. And it is by virtue of this integrative action in large part that man and the other animals express themselves by certain reactions arising in response to changes in the environment. Despite the objections that have been urged against it, and despite some obvious limitations, a modified anatomical basis seems the surest upon which to build at present. With, as I hope, a reali-

zation of its limitations, I may remark briefly upon the essential features of the method. Incidentally, the student of the scientific method may perhaps gain some idea of the diversity of the methods employed in physiology.[12]

We may regard the central nervous system as a physical rather than a chemical mechanism in the sense that, although some of the processes involved in the conduction of a nerve impulse and the excitation of a sensory ending, a central cell or an effector may be chemical, the relationships of afferent to efferent neurones are spatial rather than chemical, and our problem is not so much the problem of the nature of conduction and excitation as the problem of where the connection between incoming and outgoing impulses is made in the central system. The conduction paths traced out and the cell groups described by the anatomists afford a starting point, but they do not seem sufficient to answer all questions concerning functional relationships. The observation of the deportment of animals when some part of the central nervous system is lacking through disease or experiment and its comparison with the deportment of another animal of the same species when its nervous system and sense organs are intact is a necessary adjunct to purely anatomical study. The close and careful observation of the relation of the deportment of individuals of closely related species to slight differences in the organization of the nervous system has not been completed in most instances, but anatomical differences are observable in individuals of orders, genera or species less closely related. Observation of deportment of normal individuals, the modifications of deportment following disease or experimental procedures and anatomical description do not run unbroken parallel courses from the lowest animals to the highest; great gaps often exist in one or more lines of evidence, but some sort of a line may be traced from lowest to highest animals. Often, the three lines run parallel, and we see no apparent reason why, when all the gaps in all the lines of evidence are filled in by subsequent investigation, all should not run practically parallel throughout their courses.

The experimental method of the study of the function of the central nervous system is not particularly new. Some of the French experimenters of the early part of the last century have already been mentioned. But the method goes back even farther than this. Eckhard[13] refers to Pourfour du Petit's[14] re-

[12] See Sherrington, "Physiology; Its Scope and Method," in "Lectures on the Method of Science," edited by T. B. Strong, Oxford, 1904.

[13] Hermann's "Handbuch der Physiologie," Bd. 2, p. 106, Leipzig, 1874.

[14] "Lettres d'un Médicin à un Médecin de ses amis," Namur, 1710.

search program of duplicating the various clinical manifestations resulting from disease of the brain in man by experimental procedures on animals. Needless to say, neither Petit nor those who have followed him even unto the present day have completed this program. But in the unhappy city and country in which Petit's program was first published, there has been inflicted upon the military and civilian population a series of experimental lesions of the nervous system by a race of supermen with bullet and shrapnel bomb, potato masher, grenade, bayonet, war club and high explosive, far transcending in variety and difficulty of execution the things which he contemplated doing on animals. And because of the employment of such methods, many of man's sufferings from the war and war conditions—deafness, blindness and shattered mentality—have been more noticeable in the present war than in other wars.[15]

The experimentalist, although attacking the same general problem as the anatomist—the organization of the central nervous system—nevertheless has a somewhat different point of view. His object is not so much the mere acquisition of knowledge of the architecture of the nervous system—the knowledge of the location and form of certain cell groups, and the course of certain fiber tracts—as getting at the place where and the manner in which certain forces originating at the periphery are summed up or integrated in the central system to produce a definite, orderly and biologically adequate motor response. The method of the experimental neurologist or student of the function of the nervous system is the method of physics rather than the observational method of pure anatomy. The term integration may carry one back to his college days and the class room in integral calculus. And, so far as I understand their point of view, psychologists look at the problem in much the same way that the experimentalist does. The incompleteness of our knowledge is still as great as that of the anatomist. And the persistence in physiology of words of uncertain signification, by which we sometimes delude ourselves that we have an explanation of certain processes beyond the point where knowledge really ceases, still affords too much warrant for those who try

[15] Mott, F. W., "The Effect of High Explosives on the Nervous System," *Lancet*, February, 1916, and following issues.

Wilson, J. Gordon, "The Effects of Heavy Shell Fire on the Ear," Harvey Lectures, New York, 1917–1918. To be published in 1919.

Smith, G. Elliot, and Pear, T. H., "Shell Shock and Its Lessons," 2d ed., London and New York, 1917.

Babinski, J., et Froment, J., "Hystérie, Pithiatisme et Troubles Nerveux d'ordre Réflexe." 2me ed., Paris, 1918.

to make the public believe that the words of uncertain meaning have a very clear and definite meaning. For only on some such basis can I understand the great vogue of the large and prosperous army of quacks who prey upon the unsuspecting or credulous public under the guise of faith healers, and the like.

The reader should bear clearly in mind that we do not now know either the chemical or the nervous organization in its entirety. And in attributing any particular response or kind of deportment to either kind of organization, we are using the terms to signify what it does, as determined by observation and experiment rather than what it is.

Space does not permit a further presentation of the great mass of anatomical and functional detail which has been gathered in the course of years of study of the nervous system. The general reader who desires to get further information on a system whose study will, I believe, become of more and more interest and importance to the public in the years to come will find the salient points of the anatomy and physiology in the article "Brain" in the Encyclopædia Britannica. Professor F. W. Mott's excellent little book on "Nature and Nurture in Mental Development"[16] embodies the results of long years of careful study of problems of heredity of mental disease and other phases of the nervous system of interest to those who are interested in the social aspects of insanity and criminality.

Two minor aspects of internal organization remain to be considered; first, the organization of the heart, and then the organization of the cell. The first is of great importance for the well being of the higher animals, and the second for general biology.

The Mechanism of Coordination of the Heart

The heart, to a certain degree, has an organization of its own. It is not a chemical organization in the sense that chemical substances must be carried or conveyed from one place to another in the body fluids, but a physical organization in that a wave of excitation is conducted over physical communications from one portion to another. It is now generally agreed that the impulses leading to the contraction of the various muscular groups of the heart originate in the Keith-Flack node (sino-auricular node) and are conducted to the muscles through the bundle of His (atrio-ventricular bundle) and the Purkinje substance. But whether the substance in the sino-auricular node in which the impulses originate is essentially nervous or muscular

[16] London and New York, 1914.

in character, or whether conduction in the atrio-ventricular bundle is over muscular or nervous tissue, or whether the Purkinje substance is nervous or more of the general nature of undifferentiated protoplasm are questions which, although subjects of controversy, do not particularly concern us here. The main point is that the organization of the heart is a physical organization approaching the general nervous organization more closely than the strictly chemical organization of the organism. The frequency of the heart beat may be changed by nervous and chemical influences.

The Organization of the Cell

The study of internal organization has extended also to the simplest organisms. Brücke (1861) called the cell the elementary organism and postulated an organization other than that represented by the visible structure. Whitman (1893) again insisted upon the importance of regarding the cell as an organism. Hofmeister some years later wrote on the chemical organization of the cell. But the study of the organization of the cell for many years has been predominantly a study of the chromatin material, principally from the point of view of the microscopist. This phase of the subject lies outside of the province of physiologist. The more recent work on the properties of cell membranes and the nature of colloids does, however, come within the realm of physiology, and is to be regarded as a part of our knowledge of the chemical organization of living matter in general. Its detailed discussion lies beyond the limits of this paper.

(To be Continued)

MODERN COMMENTARIES[1] ON HIPPOCRATES

By JONATHAN WRIGHT, M.D.

Prophecy and Prognosis

A RECENT historian[2] of thought has remarked, in a somewhat limited definition, that "the aim of scientific knowledge consists in the prediction of phenomena." Here is where the priest and physician of primitive man found for ages a common field of endeavor and a sense of reciprocal support and service. On the breaking asunder of these ties, which were cemented in mutual advantage by virtue of their reputation for the prediction of phenomena "in anticipation and consequent control of events," as well as by virtue of the necessity each had for the other in the struggle for existence among uncivilized savages, medicine at first clung to the processes and practices of the priestly class of which the doctors had formed a part. The aim of science as defined by Merz, it is true, is, in a limited sense, the prediction and control of events, but it has lost that meaning which had formerly been associated with the latter term—the absorption of power and riches. As it lost this meaning and thus essentially, it seems to me, changed its aim, medicine became a science rather than an art. The methods of the priestly class, of the mystic, of the fanatic, of the idealist, could no longer suffice for this new aim, which crept into medicine under a definition which we now clearly see was not definite enough. It still strove to predict events, but its aim became not only this; it became the ascertainment of truth as an end in itself and not simply "to control events." I do not mean to assert that religion also has not in its higher realization become a search for the truth, but in the sense we now give to the phrase it was a later development and it has never become an end in itself in its higher realization, because its ultimate aim is adoration or salvation and the aim of science does not go beyond the goal of truth.

[1] The translations of Francis Adams, "Hippocrates, Genuine Works," V, 1, New York, William Wood & Co., and E. Littré's, "Hippocrates, Oeuvres complètes," Paris, J.-B. Baillière, 1839–1861, 10 v., have been chiefly used and compared with Littré's Greek text.

[2] Merz, John Theodore, "A History of European Thought in the Nineteenth Century," Vol. IV., 1914.

In the treatises of Hippocrates in the work "On Ancient Medicine" and in that "On Airs, Waters and Places," we recognize an all-embracing catholicity of thought which carries as far beyond the domain of modern medicine and into that of many scientific problems with which we are to-day concerned. Upon these I have touched elsewhere in their connection with the history of medicine. I desire here to point out how prognosis as it has later developed in the evolution of the medical art was in the time of Hippocrates intimately interwoven with the practice of prophecy as applied in other mundane activities. The discussion as to whether the "Coacæ Prænotiones" is the derivation or the origin of the other books on prognosis—"The Prognostics" and "The Prorrhetics"—is not exceptionally important to the aspect of the subject which I wish to broach here, but it is not unimportant to take notice that three books have been preserved to us, whose titles indicate that their contents are taken up with the prevision of the future. When we read them we find indeed that they are largely devoted to the description and discussion of symptoms, but they are much more occupied with the question as to whether the patient is going to get well or not than with thoughts dwelling on the nature of the lesion and its cause. Pathology, in our view, had hardly arisen yet. They cultivated the study of those etiological factors in disease only remotely, in our sense, associated with the changes in the structure and functions of the tissues. They saw clearly many links in the chain of causation to which, unfortunately, we are all but oblivious. They were presbyopes, we are myopes.

In the closing paragraphs of the "Prognostics" Hippocrates warns us that we "should not complain that the name of each disease is not written down in this treatise for all those that are terminated in the intervals of time alluded to are distinguished by the same symptoms." The rendering of this clause is rather obscure in the translations both of Littré and of Adams, and I do not know that I have improved it by amendments, but the sense is that this is a work which has to do with prognosis, not diagnosis, derivable from the symptoms. Littré takes it that this refers only to acute cases, but as it evidently has to do in the text with cases of empyema—in which term we may probably include not only effusions into the pleural cavity but phthisis, I can not see how this remark is applicable. Neither can I understand why he looks upon it as a book of special pathology, even taking into consideration the difference in the signification of that term which prevailed fifty or

sixty years ago and now. I do not think we have anything to compare with it in modern medical literature. The idea of basing a book on the symptoms solely or chiefly for the purpose of arriving at a prognosis is foreign to our way of looking at medicine to-day.

I have elsewhere dwelt upon the danger the primitive doctor ran in ministering to the ills of wild men, in having more responsibility thrown on his shoulders than he could safely bear, in being credited with more knowledge and power than he in reality possessed. To secure the latter, in his close affiliation or even identity with the king and the priest, he claimed powers we call supernatural, and, as long as this close union of church and state and science existed, it had an invulnerability which it has never possessed since differentiation began. The first to be extruded from the entente was the doctor, then after many many thousands of years the priest, and now we are hunting for the blood of kings in their last lair.

In a previous essay[3] I have devoted more space to this very significant and very fortunate incident in the early history of the evolution of thought and I will only borrow from it the story of Livingstone. Livingstone,[4] one of the most fearless and one of the most humane of men, tells of a trying and perilous predicament in which he was placed at the death bed of an old and valued friend, an African king:

> Poor Sebituane . . . I saw his danger, but being a stranger, I feared to treat him medically, lest in the event of his death I should be blamed by his people. I mentioned this to one of his doctors, who said: "Your fear is prudent. This people would blame you."

There is a passage in the appendix to the treatise "On Regimen in Acute Disease," which is to the following effect in Littré's translation. In such and such conditions of the patient "never give hellebore, for it is to no purpose; and if anything happens to the patient, they will blame the medicine." Serious consequences perhaps were not so frequent for the physician in Greece in the unfortunate sequel to the treatment of a king, but the calamitous consequences are only a matter of degree for the doctor whenever and wherever the misfortune falls on him.

Adams, incidentally in the course of his remarks on this addendum to the "Regimen of Acute Diseases," says:

[3] *New York Medical Journal*, Feb. 24, 1917.

[4] Livingstone, David, "Missionary Troubles and Researches in South Africa," New York, 1868.

I myself—albeit but verging towards the decline of life—can well remember the time when a physician would have run the risk of being indicted for culpable homicide if he had ventured to bleed a patient in common fever; about twenty-five years ago venesection in fever, and in almost every disease, was the established order of the day; and now what shall I state as the general practise that has been sanctioned by the experience of the present generation? I can scarcely say, so variable has the practise in fever and in many other diseases become of late years.

One is apt to miss an important element in the development of medicine if one loses sight of the fact that when the public are informed as to the proper treatment of disease, to bleed or not to bleed, to expose the patient to freezing air or to protect him from it—the enlightened public in another generation or two may be an obstacle to the utilization of the "real truth" —not to bleed or to bleed.

At any rate old copies of popular information issued by boards of health should be destroyed after a few years. We are continually reminded of the caution necessary to secure a proper attitude of mind on the part of the friends as to the treatment of the case and that unfavorable results may not surprise them into a hostile state of mind toward the medical attendant. Should the aspect of the case give the latter a hint as to an approaching fatal issue "death may be anticipated, and it is well to announce it beforehand," we read in the "Prognostics."

I need not go back over what I have in several places elaborated in varying ways for varying opportunities of application in connection with the matter of the divorce of medicine from religion, but there is in this dissertation on the great value set on prognosis and prophecy another opportunity to introduce it in remarking how frequently we can pick out in the Hippocratic writings instances where he sounds a note of warning of the danger medical men run in the practice of their profession. At first thought it appears that the frequency of the intrusion of this serious matter in a discourse on the theory and practise of medicine is much greater than can be noted in modern medical literature. But though we may seek in vain for it in the stately volumes of medical science, as well as in the fugitive essays of the experimental activities and the inductive observations of more ephemeral modern literature, we must remember how specialized the latter has become. If we turn to the proper shelf we shall find the tomes on legal and forensic medicine, and in the special headlines of the weekly medical journals we will find them drawing our attention rather ostentatiously to space especially alloted to the very

problems the primitive doctor faced and to which Hippocrates alluded. It required the protecting shield of sacerdotalism in Egypt to protect the former and in Asia, in the story of Democedes we find in the pages of Herodotus medical slaves crouching in the dust before the king of kings, Cyrus the Great and Darius, or their writhing bodies impaled on the spears of his palace guards, and two thousand years later the relatives of the Turkish pasha whom Zerbi treated at Constantinople, tore the unfortunate doctor and his hapless son limb from limb because of the unexpected death of the patient. Prophecy and prognosis are in such a state of society or in anything approaching it very pressing and important departments of medical science. Hippocrates therefore is speaking pertinently when he says when death is anticipated "it is well to announce it beforehand."

The lay public has always been anxious to ascribe to the practioners powers which the wise among them are continually at pains to disclaim. The accounts of innumerable suits for malpractise which to-day fill the special columns of medical publications and the bulky volumes to which I have alluded remind us that Molière in echoing a jibe older than Petrarch or Pliny or Pindar was but speaking to the point in placing such words in his false doctor's mouth. Sganrelle's conception of the vantage ground on which he stood is a false one, quite consistent with the character of a médecin malgré lui, congratulating himself on the advantages of the doctor's calling, but blissfully unaware of its dangers. Molière was not speaking at all from the fundamental situation which underlies the relation of doctor and patient but in revealing the state of the public mind in the time of the *grand monarque*, he is uncovering for us in the study of the history of medicine an ever-lurking menace to the doctor. He reveals the attitude of the laity in an epoch of high civilization, looking with suspicion on the manner in which doctors employed the power of life and death they were believed by the common people to possess over those who submitted themselves to their ministrations. Sganarelle says:

> Que c'est le métier le meilleur de tous: car, soit qu'on fasse bien, ou soit qu'on fasse mal, on est toujours payé de même sorte. La mechante besogne ne retombe jamais sur notre dos; et nous taillons comme il nous plait sur l'étoffe ou nous travaillons. Un cordonnier, en faisant des souliers, ne saurait gater un morceau de cuir qu'il n'en payé les pots cassés; mais ici l'on peut gater un homme sans qu'il en coute rien. Les bevues ne sont point pour nous, et c'est toujours la faute de celui qui meurt. Enfin le bon de cette profession est qu'il y a parmi les morts une

honnetété, une discretion la plus grande du monde; et jamais on n'en voit se plaindre du médecin qui l'a tué.

Now I fancy this is the reason we find in ancient Greece prognosis taking the lead rather than diagnosis in the titles and thoughts of the authors of the treatises of the Hippocratic collection, for in free Greece exposed to the fury of the populace and out from beneath the shield of sacerdotalism, unprotected by king or court, it was well indeed to be a little "beforehand" in anticipating death and disaster. Thus prophecy was a very important element indeed in the equipment of the early Greek doctor and prognosis received an attention of which our courts of justice have deprived it to some extent.

If a modern physician stops for a moment to take an inventory of his own field of mental activity he will, I think, find that prognosis does not occupy a very large part of his thoughts in regard to his patients and still less those in regard to the diseases from which they suffer. It is true that in proportion as the practitioner is removed from centers of medical discussion and is confined by necessity or confines himself from choice almost entirely to the practical aspects of his avocation, in the sense of managing the patient as much as his disease, with eyes open to his own financial and social interests, he will be found making more shrewd guesses from the symptoms as to whether his patient is going to recover or die. It is not the lesion and its cause so much as the practical result of the condition in which he finds his patient. Adams likens him to the anxious pilot looking out for storm ahead and in this view of the importance of prophecy or prognosis, expressed or suppressed, he wonders why this branch of semeiology is no longer cultivated by the profession. The answer I think is quite evident to us. There are not so many storms ahead as there were in the days of Hippocrates, when medicine was being weaned from the nursing care of the temples of religion. The doctor found it more difficult than the priest to point out that the unexpected death of the patient intrusted to his care was due to the hand of God.

Now it is indisputable that less dangerous emotion was aroused in the breast of primitive man and to-day the shock is softened if the patients' friends can be prepared beforehand for a fatal issue. If they can be impressed with the seriousness and the danger of the condition, the prophecy of ultimate recovery may easily be so worded as to reflect credit on the doctor for a favorable result which he shrewdly judges is pretty liable to occur anyhow. So it appeared to Hippocrates

a most excellent thing for the physician to cultivate Prognosis; for by foreseeing and foretelling, in the presence of the sick, the present, the past and the future, and explaining the omissions which patients have been guilty of, he will be the more readily believed to be acquainted with the circumstances of the sick; so that men will have confidence to intrust themselves to such a physician. And he will manage the cure best who has foreseen what is to happen from the present state of matters. For it is impossible to make all the sick well; this, indeed, would have been better than to be able to foretell what is going to happen; but since men die, some even before calling the physician, from the violence of the disease, and some die immediately after calling him, having lived, perhaps, only one day or a little longer, and before the physician could bring his art to counteract the disease; it therefore becomes necessary to know the nature of such affections, how far they are above the powers of the constitution; and, moreover, if there be anything divine in the diseases, and to learn a foreknowledge of this also. Thus a man will be the more esteemed to be a good physician, for he will be the better able to treat those aright who can be saved, from having long anticipated everything; and by seeing and announcing beforehand those who will live and those who will die, he will thus escape censure.

I will not stop to inquire as to the reasons for receiving or rejecting the second book of the "Prorrhetics" as a genuine work of Hippocrates further than to remark it bears the imprint of some master hand. The question of its authorship is sufficiently discussed both by Littré and Adams, though it is found only in the edition of the former. The author, whoever it may be, continues in a train of comment entirely in keeping with the first paragraph I have just quoted from the "Prognostics"; indeed, the thought seems continuous. He says:

They quote the prophecies of doctors many, admirable, marvelous, such as I have never made myself nor heard any one else make. Here is one kind. A patient appears without any chance evident to the doctor who has cared for him or to other people; a second doctor comes along who proclaims that the patient will not succumb, but that he will lose his sight—

or it may be he will be lame of one arm—or that he may recover indeed but will have gangrene of one of his toes, or they have eaten something or drunk something or done something which is responsible for their conditions.

As for me I take note of the symptoms from which I may form some opinion as to who among my patients will recover and who will die, who will die or get well in a short time and who after a long time. I prescribe then for the lesions and indicate how each is to be regarded.

The opening phrases of these two books when taken together exhibit a common sense and a shrewdness and an appreciation of what is both prudent and seemly in the practitioner which at least in the simplicity with which it is set forth rises to the level of genius. He tries to explain how these seemingly

rash prophets arrive at their prognoses and how they elude discomfiture, but this does not interest us so much as another matter. This class of persons who incur the displeasure of the author by their propensity to "bluff" includes individuals who concern themselves not only with the prognoses of disease, but busy themselves with another sort of prophecy. Insurance offices were not yet opened to the venturesome man of business who still desires to cast an anchor to windward occasionally. Xenophon led an adventurous life and got into all sorts of unpleasant scrapes, and, evidently to keep out of them, he kept a prophet, like a medieval astrologer, by his side. It was a part of the prognostics of these prophets to whom Hippocrates refers to point out "to people whose occupation is business and venturesome enterprise, deaths for some, insanity for others, other diseases for others, prophesying in all these matters for the time ahead without ever making a mistake." He makes no reflections on the ethics of doctors who thus go around giving tips to business men as to people on whom they have to depend for carrying out their schemes. Perhaps he saw no harm in it at all. It has remained for modern life to capitalize prophecy and to back it with hard cash. Up in the top rooms of the skyscrapers along Broadway are medical men busy advising those who take chances on future events, who are going to die and when. They draw horoscopes and guarantee them. Xenophon's prophet drew the horoscopes, but it was a precarious job at best and without a guaranteed policy, issued for cash paid down in the form of the prophet's board and lodging. It soon became a neglected art, but it has been revived in London and Liverpool and New York in later times.

After Greek business men and soldiers of fortune gave up their prophets, the latter disappeared from history and do not emerge into prominence until the Arabian astrologers penetrated Christian precincts and we find them again at the elbow of the greedy, the lustful and the venturesome. In history, even, they appear in the Middle Ages as sinister figures, while among the novelists of the later romantic period they often appear as the arch villains of the plot. Scott made them so unpopular it seems almost like sacrilege to recognize in the medieval personage of the astrologer the connecting link between friends of Hippocrates and the medical directors of our life insurance companies.

When we apply ourselves to the texts themselves of the several books we find that the author by no means confines himself to discussing those appearances and internal symptoms of

the patient which can be used in forming an opinion as to whether the patient will die or live. Even where he does, as in the celebrated passage of "The Prognostics" on the facies of death, he describes appearances so striking that it scarcely requires the education of a medical man to discern in them the death agony. It is, however, the phenomenon itself which confronts the student when he engages first in the study of medicine. This is the condition he is expected to avert or whose onset he is to strive to delay in his future practise. It is in fact the central point in his field of interest. This state is the one which forms an excuse for many things he must insist upon in the regimen of the patient, this is the state to avoid which men will obey him and pay him eagerly all he asks. Despite its obvious nature then it finds its proper place as the first instruction the reader receives in studying the art of prophecy. It belongs in the category of prognostics as directly bearing upon it, but immediately we find the discourse wanders off into paths which quickly disclose to us the vistas of the practise of medicine as an art resting upon observations capable of apprehension by senses trained by their exercise. Prognosis *is* the practise of medicine for the wary Greek doctor. He wants to know not for the joy of knowing in itself, but for his behoof in making his way in the world and avoiding disaster. The title pages of these books therefore bear on their face evidence of the way the old Greek doctor looked on his profession. I think we are near the truth and not over-presumptuous in declaring that is not the typical attitude of the best part of the profession to-day. It is *not* now the first thing which occurs to the modern doctor as he enters on his profession or on his duties in attendance on the sick that "by seeing and announcing beforehand those who will live and those who will die he will thus escape censure."

I may thus be seeming to cast aspersions on the ethical nature of Greek ideals from a very singular elevation for the purpose—the solicitude of the doctor for his patient's future, the desire to soften the blow to the friends by preparing them for the worst. Surely in this day of altruism we have every reason to look upon such motives with approval. In the Spencerian philosophy we were taught how such altruistic sentiments arise from self interest, how sympathy and compassion arise from the inward reflection that the pain may be our own some day, this feeling growing in intensity to the point of actually feeling the pain and sorrows of others as our own in some sensitive natures. However indisposed we may be to explain

away all generous sentiments in our nature in this way, history plainly points out to us that this appreciation of the importance of prognosis on the part of the Hippocratic writers arose not so much from the disinterested impulses of nascent humanitarianism as from a knowledge of the consequences likely to follow from the resentment of friends and relatives who inherited the primitive idea that the issues of life and death are in the hands of the doctor himself.

If we turn to scan the actual words of this famous sentence on the facies of death, "*a sharp nose, hollow eyes, collapsed temples; the ears cold, contracted, and their lobes turned out; the skin about the forehead being rough, distended and parched; the color of the whole face being green, black, livid or lead-colored,*" we get a picture which has become classical in many literatures. Lucretius threw it into Latin verse and Celsus into Latin prose. Shakespeare's striking description of Falstaff's death-bed in words of Dame Quickly is also referred to by Adams:

> For after I saw him fumble with the sheets, and play with flowers, and smile upon his fingers' ends, I knew there was but one way: for his nose was as sharp as a pin, and he babbled o' green fields.—So he bade me lay more clothes on his feet: I put my hand into the bed and felt them, and they were as cold as any stone, etc. (Henry V., ii, 3).

Having quoted this familiar passage, Adams incidentally says in a footnote that he can not forbear to remark "that it appears to be rather out of character to make the wandering mind of a London debauchee dwell upon images of green fields." He thinks when such a person comes to die, his imagination would dwell rather on bawdy houses and drinking taverns. The old villain may well once have been a country lad attracted by the lights of the great town. The memory of age and the dreams of senility are those concerned with the scenes of our youth and he may well have "babbled of green fields" which wine, women and song had banished from the years which had intervened. Dame Quickly would hardly have noticed it if he had babbled of the lechery and drink of taverns. An incapacity to perceive wherein lies the genius of Shakespeare is not a very good equipment for the study of Hippocrates and a closer parallel to Shakespeare's description of the death of Falstaff can be found in another passage[5] in the Hippocratic writings, as I have elsewhere pointed out.

Notwithstanding the graphic realistic and impressive nature of the phrase in the "Prognostics" on the facies of death,

[5] "Epidemics," III., Case XV.

Hippocrates begins at once, in the same clause, to modify it, the earmark also of his genius, the incapacity not to realize that every phenomenon has a twofold aspect at least—that there are two sides of the shield to be inspected despite the neat thing he had said. Some of the symptoms may perhaps warrant a different prognosis. Perhaps the patient has slept badly, suffered long for food when first seen and this has put on him the impress of death. It is perhaps better to wait a day or two and see if the picture persists, or perhaps the patient has suffered two or three days from an attack of cholera. These cautious doubts flit through the mind of the careful practitioner and make him suspicious of his smartness at epigram: but after all —"all these are bad and fatal symptoms" and usually "death is close at hand." This is the difference between prophecy and prognosis. This is the difference, almost antipodal, between a prophet and a man of science, so wide apart have they grown who were once brothers. Hippocrates did not belong in the prophet class.

THE COMMERCIAL CONTROL OF THE MINERAL RESOURCES OF THE WORLD: ITS POLITICAL SIGNIFICANCE

By J. E. SPURR

OUR modern civilization and progress is largely a matter of more powerful and finer tools wherewith to control more and more the forces of nature and direct them toward advancing human comfort, convenience and power. These tools are constructed mainly from the metallic elements and minerals in the earth's crust. Breaking away from the use of wood and stone, hardly more than a hundred years ago, coal and iron made possible the railroad, the steamboat, steel bridges, ships, tunnels and canals, with the consequent beginning of the uniting of the peoples of the civilized world into a commonwealth. Nations became powerful as they possessed, or had free access to, coal and iron. Next with the development of electricity, copper became essential; by this means the telegraph, the telephone, the transmission line for power plants were made possible, and the substitution of hydro-electric power for steam. With the development of steel, more powerful materials became possible through alloys of steel with rarer metals, such as nickel, chromium, vanadium, tungsten, molybdenum and these latter became each in its way increasingly important. With the invention of the gasoline engine the oil concentrations in the crust came to rival in importance the coal fields, for thus was made possible the automobile and the airplane.

The races of men cover the land of the globe, save where the cold is too intense, at the poles; and also save where fresh water is scanty or lacking, for without water there can be, according to the terrestrial plan, no life, whether animal or vegetable. Everywhere else, in all lands, vegetable foods which feed the race may be grown. Wheat encircles the earth, in both hemispheres.

But the metallic elements which are found throughout the earth's crust are segregated or consolidated so as to be easily won by man in special restricted areas, not defined by latitude or longitude. Nor can such ores be transplanted or made by

human ingenuity to develop in spots where they do not exist. The culture of corn, potatoes and tobacco may be carried from America to Europe, and the breeding of horses from Europe to America, and thus original economic advantages may be obliterated, but not so with the mineral kingdom.

The occurrence or lack of these mineral concentrations in the lands occupied by a race constitutes, therefore, under the present system, one of the most fundamental and unalterable advantages or drawbacks to progress. The race possessing the fullest complement of these metals, in quantity, tends to increase most in power. The race that has them not, or not in due proportion, must, if it is to keep pace, obtain them, either by conquest or by trade, or both. The struggle for the borderlands between France and Germany, including Alsace-Lorraine, was a struggle for coal and iron.

The natural boundaries for autonomous states are those of race, tongue and geography; but the extent and forms of empires, and of their tentacles have been and will be determined by natural resources, chief among which are the fullest complement of the metals; and so it will remain until the world-federation, with free trade by sea and land.

Probably no nation has seen this so clearly as Germany. She had to, being relatively poor in natural resources.

Of all great nations (save, perhaps, the old Russian Empire) the United States has within its boundaries the greatest mineral wealth; and perhaps least of all great nations has realized its political significance. The United States possesses vast iron, coal and oil reserves; the richest copper districts of the world so far developed (probably only South America will rival them) and adequate lead and zinc deposits. Hence in large measure the rapid rise of the United States to power and wealth; hence her fitness for leading the world in civilization. She has the sinews of war, of peace and of growth.

Two elements of weakness in this respect present themselves. First, the lack of full development of internal resources, because in many instances it has been easier to trade than to develop. This defect the present war has in part remedied; and we should look to it that it is studiously remedied in the future. Germany possessed (before she lost Alsace-Lorraine) the only large resources of mineral potash in the world, and therefore deemed herself in a position to dictate to other nations and exact supplies of other raw materials, such as copper, rubber and cotton, which she must have. Nevertheless, we have vast stores of potash, especially in our silicate rocks,

which stores we have slowly developed under the stimulus of high war prices; and it seems entirely probable that we can, if we wish, supply ourselves entirely from domestic sources. Second, there are mineral resources in which our country is poor or lacking. Natural supplies of tin and platinum, for example, are practically wanting.

The possession of great resources by a country is not final as an advantage; for in the end it is not political but *commercial* control which gives rise to power, wealth and the growth of individual civilizations. Small nations and even lone cities have become powerful and dominant in proportion as they spread their web of commercial control over wider and wider areas. The old example of Phœnicia will come to mind, and later and more especially, Venice, and still later the Free Cities of Germany. The cramped islands of Britain drew the inhabitants to the sea, to voyaging and trading, with the consequent growth of a great empire and the attendant necessity of becoming mistress of the seas. Holland at one time furnished a similar example, as well as Spain, and even Portugal.

As the power of these great commercial nations, as well as their commerce itself, depends upon their fleets, so it is great naval battles that have in many cases signalized the fall of great world powers. The defeat of the Armada ended the control of the seas for Spain; the sweeping from the seas of Van Tromp's fleet for Holland; and by these and other naval victories Great Britain achieved her world predominance, which she can maintain in no other way than by her present naval policy.

Many of us have wondered what Germany meant by the "freedom of the seas." What else than relief from the naval control of Great Britain? Freed from this, the German navy would soon have strengthened and extended her overseas empire. The freedom of the seas can mean little else than that Britain shall so equalize her navy with that of other great powers that the navy of each of these shall have as equally impressive an influence (on minor as well as upon major peoples) as has that of England. We ourselves know well the valuable regulative power of a show of battleships and perhaps a landing of marines. "All very well," reflects Britain, "but how shall we police our world-wide empire against these very peers and commercial rivals of Britain unless our navy is preponderant; and what other nation has such a scattered empire to guard?" In truth, the control of the sea-lanes to Canada, India and Australia, is to Britain what the control of our transat-

lantic railways and of the Panama Canal is to the United States.

The commercial control of mineral and other natural resources is normally followed by political control. Spain sent expeditions to Mexico for gold and the Conquest was the result; much as in modern times, the English adventured in South Africa for gold and diamonds, with the consequent disturbances which ended in a war of conquest. To this day, as the underlying cause of great political events, careful scrutiny will often discern the necessity for minerals. The rôle of Mexico's mineral resources, especially oil, in her recent tempestuous history has yet to be unearthed from the secret archives and made clear.

Commercial control may be secured by political control, or may exist independently of it. We imagine that because the United States possesses great mineral wealth, she is, therefore, in a position to dictate to other nations, to withhold or supply. Does this follow in the case of China or India? On the contrary, it becomes a source of weakness unless coupled with commercial control. Where commercial control lies outside of China or India, the people pass under foreign domination along with the natural resources of their countries. It was with great good judgment that the Mormons hunted away the prospectors from Utah and forbade mining, knowing that the powers of the Mormon State would fall when mineral wealth was developed.

We fail to realize the quiet, incessant and invisible power of commercial control, working intricately and efficiently in a thousand ways, often almost, or quite, beyond the control of governments. In times of war a nation may set up partly successful barriers between its wealth and the grasping hands of other peoples; in times of peace there may more easily develop, unfettered, vast commercial empires whose boundaries do not by any means coincide with the political empires, and which possess great power, and shape the course of history.

What are we going to do about it? The first thing to do is to understand the facts and the essential elements of the problem. We must make a preliminary survey of the world to see, separately, where each of the essential metals is segregated into workable and valuable fields. Incidentally, we will note in what geographic boundaries and under what governments these great deposits lie. Next we must see who really owns them, what companies, where incorporated, and how controlled; and who owns the stock. But that is not all, nor most important. The key to commercial control lies not in the nationality of the stockholders, but in the nationality of the *capital* behind the

enterprises. This is not always easy to find out, but it must be charted as accurately as possible.

For us, one of the principal lessons of such a study will be that the United States Government must protect and encourage the investment of American capital in mineral wealth. (I write only from the standpoint of the study of ores.) It must do this in the United States, else we shall have our resources dominated commercially by foreign capital, close upon the heels of which normally follows foreign political influence and guidance. We must do it in minor countries which look to us for support, especially the minor American republics which we have long defended from European and Asiatic aggression and domination. The Monroe Doctrine, if held to, must be applied to commercial as well as political control. Germany at the outbreak of the World War had gone far toward establishing outposts of her commercial empire in certain parts of South America, which were fast becoming parts of her empire politically. Her progress would probably have been consummated had she not brought on the war; indeed, she was in a fair way to have established a commercial outpost in the United States, which would have affected the political control of our own country.

Commercial strength lies in the combination of capital, and only by recognizing and encouraging combinations of American capital engaged in mining can the well-organized foreign combinations of capital be offset and checkmated. The government should see to it that such companies are loyal and American, for loyalty in commerce is as important as loyalty in politics, and these companies the government should guide and control, in proportion as their size and influence increases, considering them as they grow, to merge gradually into what may be considered essentially public utility companies, to serve public uses, just as the railroads have been considered to be; and a full understanding and alliance should be made with such mining companies, who should understand the need and right of government direction. Herein—in the power and science of capital—lies much of the future of history, only it must be directed and handled for the common good. If we do not use this science of capital, we shall be easily outdistanced by more highly organized nations.

It is, perhaps, not too much to say that some economic or commercial reason lies behind nearly every political tendency and event, the sum total of which makes up history. I do not refer exclusively to the influence of capital. It may be the influence of labor or of the great mass of consumers. Most potent

will be this impulse where the influencing interests are best organized, and it is of course for this reason that the combinations of capital, no matter how justly they operate, are so powerful. The present stage of the world is the stage of organization and combination, and there have developed, in all advanced countries, very strong associations of capital interested in or even controlling certain industries the world over. It is idle to think it is possible to break up these combinations of business which like combinations of governments must, in the necessary course of evolution, grow stronger. It is, therefore, essential to study these forces in order that they may be coördinated and controlled. The remedy for the consumer and the laborer, against anything but benefits from such organized efficiency, lies in their exercising over it, through their governments, the control necessary to safeguard their position and to better it.

Modern invention, increased facility of communication, and modern time-saving and distance-eliminating discoveries, have led inevitably toward both commercial and governmental combinations. The progress from the prominence of state government in the United States through the strong federal control system, the constant accretion of territory and spheres of influence, and finally the plan of the world-combination of government, was the result of the same inventions which led commerce in all countries to gather in larger and larger pools, which finally became national and are now international.

A single example (among many available) of the problems of political and commercial control of minerals may be briefly cited. Petroleum will apparently be to the future what coal has been to the past—predominant in importance on the land, in the air and on the water—through the automobile and tractor, the airship and the modern petroleum-burning steamship, which apparently will largely supersede the coal burner. The control of petroleum production, and especially of strategic oil bunkering, will control the seas and commerce, in the interest, if need be, of the controlling nationality. Some extracts from an unpublished article by John D. Northrup, oil specialist of the U. S. Geological Survey, will illustrate this problem:

Position of the Leading Powers

United States:

With respect to developments expected in the petroleum industry, within the next decade, the position of the United States, thanks to the enterprise and foresightedness of financial interests of domestic origin, is apparently strong. United States interests are practically supreme in the

commercial control of the petroleum resources of the Western Hemisphere, dominating the petroleum industry in the United States, Canada, Mexico and Peru, holding substantial interests in Trinidad and Venezuela and in the prospective petroliferous areas in Central America and Colombia. Its only competitors are British and British-Dutch interests, which control the petroleum situation in Trinidad and are not only strongly intrenched in the United States, Mexico and Venezuela, but are aggressively seeking to enlarge their holdings in those countries and to gain footholds elsewhere. Unless the United States adopts measures to limit the aggressions of foreign capital in this country, such as federal operation of the trunk pipelines, and adopts either a firm forward-looking governmental policy toward the protection of investments of its citizens in petroleum properties in other countries, particularly Latin American countries, or adopts the more radical but amply justified policy of direct governmental participation in petroleum developments in other countries, it may witness its commercial supremacy in petroleum affairs wane and disappear, while it is yet the largest political contributor to the world's supply of petroleum.

Great Britain:

British and British-Dutch interests easily dominate the petroleum situation in the Eastern Hemisphere by domination of the petroleum industries of Russia, India and the Netherlands East Indies. The strength of Great Britain's present position in the World's petroleum affairs lies in a strong governmental policy in the matter and in the wide scope of British petroleum investments, embracing practically every country of which petroleum is an important product and nearly every country of which it is a product of potential importance.

France:

Since control of the petroleum interests of the Rothschilds passed into the hands of the Royal Dutch-Shell Syndicate (British-Dutch), the influence of French finances in petroleum affairs has been negligible, outside Galicia and Italy, where its influence was not great. At the termination of the war French capital will undoubtedly participate in efforts to determine the petroleum capacity of the Barbary states, French dependencies, but that it will be appreciably involved in organized efforts to control the world situation with respect to petroleum is not anticipated.

Japan:

Japanese investments in the world's petroleum industry have not yet attained significant proportions outside Japan itself, though the Japanese government is officially alive to the importance of Japanese investments in petroleum properties in Mexico, particularly Lower California and Sonora, China, and undoubtedly Russia, and large investments of Japanese capital in the petroleum industry in one or all of those countries may be confidently expected in the near future.

More recent developments in the oil industry, since the above was written by Mr. Northrup, serve to emphasize the tendencies which he describes.

These quotations furnish the key for our future American

policy. Such mineral wealth as we possess in an exportable surplus must be managed for our best advantage. Such minerals as we do not possess in quantities sufficient for our own needs must be secured to us so far as possible by a definite and intelligent governmental policy.

I may digress somewhat to point out what appears our present best national policy as regards our own scanty supplies of this latter class of mineral commodities. There is at present an agitation among certain portions of our mining industry for the protection of some of these mineral industries which have developed through the stimulus of war shortage and high prices, and for rendering them permanent. From the national standpoint this would be shortsighted. We would be consuming our scanty reserves and would be impoverished in this respect more and more in the future. It is much better, for example, to trade our surplus of cotton and copper for the high grade chromite and manganese of other nations, being sure, however, to adopt such a moderate policy that our own reserves of such ores, in part at least, are readily available upon emergency.

Students of foreign trade in ores and of the mining industry of foreign countries, as well as our own, have noted that the competition of combined commercial interests other than the German, exists under official or semi-official guidance, and that, for example, the policy of the English in this regard is a very strong and deliberate one with which we have to count. This development is a natural one and we find the same impulse in American thought. Note, for example, our frankly expressed plans for capturing foreign trade and for having our merchant marine predominate on the seas. We can not, of course, do these things without taking wealth and power away from England and other maritime nations. Hence it is the right and intelligent policy for these nations to further their own interests just as we plan to do. However, if our policy is to be self-protective and nationalistic, as we state so openly, assertions are not enough: we must back these up by direct government encouragement and protection, such as is afforded the British and other nationalities by their governments. Americans, for example, or American companies (together with other foreigners) are debarred from owning or operating oil-producing properties in the British Isles, Colonies and Protectorates; but British-controlled companies have important holding in the oil fields of the United States, which they are extending.

In some of the mineral commodities, it seems very possible that there will soon develop, if there does not already exist in

some cases, a world shortage which may tend to grow more stringent, since the development of the arts requiring these materials will undoubtedly grow rapidly, while the natural supplies of these materials may not be increased in proportion. Therefore, there will be necessarily sharp competition between the United States and its best friends, such as England and Japan, as well as between us and our former enemies. This commercial struggle will have a certain tendency to terminate in the future precisely as it has in past history—in commercial and political intrigues, in bitterness of national feeling, and in wars. We may liken the commercial struggles of the respective nations to the cut-throat competition of rival commercial houses. The historic commercial-political struggle for the fur trade of North America between the British Hudson Bay Company, the French companies, and Astor's American Company in Oregon, is essentially what we may deduce in principle as the result of all great struggles for the enlarged trade and greater wealth of nations at the expense of each other. Speaking in the language of commerce, is this good business? Will it pay in the long run? Has it paid? Did it pay Germany, our best example? A continuation of this competition means for England an absolute necessity of keeping by means of her fleet the position of mistress of the seas. It means for America a program which has already been put forward, viz., the program for building a fleet as large or larger than England's. Competitive matching of navies to protect the commerce of their respective countries will end in the same way as competitive matching of armies—in war.

The only reasonable solution would seem to be for the rival houses to amalgamate. The plans for a league of nations are now under consideration, but there is grave doubt as to whether they will mature satisfactorily. If many nations, large and small, with different ideals shall seek to form a union, then it may be feared that no practical results will arise. It seems not only feasible, however, but imperative that the three nations which stand abreast in the forefront of civilization and are highest developed as regards fairness and good will toward the whole world, viz., the United States, Great Britain and France, should amalgamate for their own and the world's good, and agree upon a firm central policy with plans looking forward toward reciprocity or free trade, so far as it is fair, among themselves. Treaties will be no good; history has shown them to be what the Germans cynically termed them—"scraps of paper." The world has already tried a central judiciary and

has gained some fragments of international legislation but these have been of no avail to prevent war. Any league to be effective must be bound, not only by a central judiciary, but by a central legislative body, executive council, and a central military or police force by land and sea. But of even greater importance is the principle that for any league of two or more nations to be effective and permanent there must be commercial, as well as political alliance. The political league of the United States of America would not last long if there were interstate tariffs and discrimination in commerce by one state against the citizens of another.

Let this federation of the English- and French-speaking peoples be formed as a first step, and let it be tried out. By itself alone it would guarantee the world its peace. Other nations would be on probation and would be admitted one by one as they showed themselves desirous and competent, just as the territories of the United States have been admitted one by one to the brotherhood of states. This triple federation would safeguard the rights of peoples outside of the federation, to be well governed, to have their government administered for their own good, rather than for the advantage of exploiting powers or individuals. This does not mean that every state or tribe in the world should have the same voice in the world government as others. The Afghans can not have the same influence individually or collectively, as the Americans or British, except as they develop and show themselves more and more worthy, but it is the right and duty of the most advanced individuals and nations to see that nations like Afghanistan and India have the same fairness of government administered to them as the Americans or British.

FEUDAL TIMES IN VENEZUELA

By Professor A. S. PEARSE

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VENEZUELA has lately excited considerable newspaper interest and gained a rather unsavory reputation in the United States on account of its supposed pro-German sympathies. There have been rumors of submarine bases on the Venezuelan coast, of the proposed sale of an island to Germany, and other more or less wild tales. During the past summer the writer spent six weeks in Venezuela and was surprised to find that ninety-nine per cent. of the people were heartily in sympathy with the United States and the allies in their war against Germany. He became well acquainted with members of the president's family and heard President Gomez express his views on various matters of state, both foreign and domestic. This article attempts to give a true picture of conditions as they exist in Venezuela. If we are going to have business and political relations with South America, we must begin by understanding the conditions, customs and ideals in the countries with which we deal.

Venezuela is a beautiful mountainous country with great natural advantages. The mighty Orinoco drains the greater part of its area. There are fine grazing lands, fertile plantations and valuable mineral resources. Its three million people are intelligent, courteous, hospitable and good natured. Caracas, the capital, is a beautiful city nestling in a great natural bowl surrounded by mountains. This city is the most "stylish" the writer has ever visited. People are extremely well dressed. Every clerk carries a riding crop when he goes abroad in the evening.

All this fair country is owned by General Juan B. Gomez. To be sure, General Gomez does not have the actual title to all its estates, but his will is absolute and he may confiscate what he wishes at any time. He gained Venezuela, like the feudal barons of old, because he was and is the strongest man in it. When he retires the country will not be handed over to his son, nor to any one who may be elected president—*unless* this successor is a strong man. Castro was a strong man and a brave one. Gomez was the trusted commander of the army that made

"KIDS."

his government possible. When Castro's wild and erratic behavior compelled him to flee, Gomez took over the country by a "bloodless revolution."

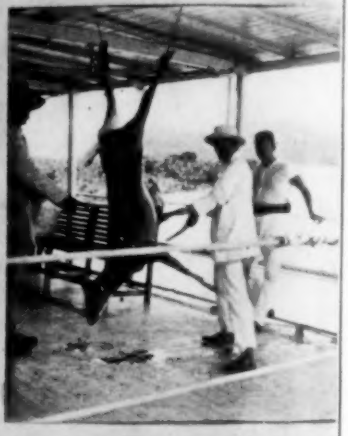
Gomez was elected president (every one of the little countries in Central America and the upper half of South America has a perfect form of government, on paper, and the laws are punctiliously observed, on paper). But having spent his days as a rancher and soldier, Gomez had no taste for an office-holder's life. He therefore appointed another man to wind the presidential red tape. Venezuela now has an "acting president," who does the administrative work, and a "president elect," who tells him what to do. This shows how much power Juan B. Gomez has. It also shows that Gomez is no weakling who received his inheritance from a proud but incompetent parent. Nor was he elected president because he could make a good stump speech; nor because he hired a big newspaper. His political machine was built of soldiers.

Under the present administration the people of Venezuela are better off than they have ever been before. On this account Gomez is generally respected and admired by his retainers. One of the general's hobbies, which he preaches constantly, is that every one must work—and in a real "mañana" country such an idea is revolutionary. Some of the old régime, who lay in soft berths as office-holders during Castro's time, are grumbling at home in amazed discontent, but people generally are rather pleased with the new order. One who works is now sure of some reward.

General Gomez is also liked because he has in general been just in regard to property and family rights. Though confiscation of land and other property by the government was an old, established, and of course always strictly "legal," means of income for office-holders in Venezuela, it has been administered with a considerable degree of justice since Castro's time. Of course, there are still abuses; politicians can not learn new methods in one generation. To-day it is much easier to get foreign capital into Venezuela than it was ten years ago, and

ON THE ISLA DEL BURO OUR PARTY SHOT THREE DEER IN AN HOUR. There are few game laws in Venezuela, but the slaughter of birds for plumes is prohibited.

Two of the deck hands on a steamboat. There are no child labor laws in Venezuela.



A caballero.

the "willingness" of capital is a good index of a country's stability.

Venezuela, though constitutionally and formally a republic, is actually as much an absolute monarchy as Russia ever was. The power of General Gomez is complete, and with this condition the virtues and evils inherent in absolutism obtain. The discipline throughout the country is like that of an army. One who commits a misdemeanor is speedily clothed in a fiery red convict suit and put to work twelve hours a day. Such quick justice is conducive to good behavior. The country is in general orderly, safe and quiet.

But "justice" is not always just. Unlimited power permits officials to vent private spleens. Sometimes men—often they are men of ability and prominence in the community—are thrown into prison overnight, and no one dares ask why. If the necessity arises, it is easy enough to find perfectly adequate legal reasons for such cases. On this account, foreigners who live in Venezuela do not often become citizens of the country. One specific instance will make conditions in this connection plain. A mechanic in a factory was told to come on Sunday to do some extra work. The man did not appear and

said on Monday that he had been sick. The owner of the factory, being a man of influence, sent the fellow on an errand; then called up the police station and gave orders to have him put in jail and kept there until orders were received to let him out. The workman stayed in jail two weeks.

Unlimited power is responsible for the detestable concessions, characteristic of most Latin American countries. In Venezuela it is customary to let the concession for selling stamps. One buys a stamp in one place and mails his letter elsewhere. There are government concessions for manufacturing, for selling, for transporting, for owning land. With power centralized as it is, these concessions are bound to be granted in many cases as rewards for political or military service or sold to those in favor with the government. Thus a few persons have most of the chances to make money. There is no general opportunity for everybody. A peon's son is expected to be a peon himself, and can rarely rise to a better position.

Culturally, Venezuela is of course rather backward when compared with more progressive nations. She has had and has some very good painters, as the admirable work in the National Art Gallery shows. There are excellent musicians and music is generally much appreciated by the better classes of people. There are a few good doctors, lawyers and teachers. The great mass of the people, however, are rather illiterate and the elementary schools are largely in the hands of the church. Domestic arrangements are usually rather primitive and often unsanitary, even in the cities. Cooking is done over charcoal

Bulls are the commonest draft animals in Venezuela.

VENEZUELAN GARDENER PLANTING YOUNG TREES. Seedlings are reared in joints of bamboo. When they are set out, one side of the "pot" is split off to allow the roots to spread, and the whole buried in the ground. In this way the roots are not disturbed and the bamboo as it decays furnishes nourishment for the young plant.

fires on the ground, or on an earth-covered table in the kitchen; the smoke being allowed to escape through holes in the wall. Most of the houses are made of clay with tile or thatched roofs. The natives are accustomed to close all the openings of bedrooms tightly at night, and, as would be expected, tuberculosis is prevalent.

But the next generation will see marked changes in Venezuela. There is a crying need for more and better opportunities for education. Caracas has already established two excellent trade schools, one for boys and one for girls. Even in the country districts one meets ambitious fellows studying at night to improve their position.

Under General Gomez the roads throughout Venezuela have been greatly improved. It is now possible to go comfortably from La Guaira to Porto Cabello by automobile. Concrete houses with yards about them are appearing here and there in the country districts. These are coming into favor and will undoubtedly in time replace the Spanish type of house (built of adobe clay around a central court)—which, though well suited for defense against attack, is neither pleasant nor sanitary.

In Venezuela the standards for chastity are somewhat dif-

ferent from those prevailing in the United States. The women in Venezuela are as careful in the observance of their moral code as those of any country, but their standards are not those commonly observed among English-speaking nations. One illustration will make conditions clear. President Gomez, though he has never married, is estimated to be the father of some hundred odd children. The laws of Venezuela permit a man to legalize the children any woman not his wife may bear, and the president has made such procedure for two families, which therefore constitute his legal heirs. Any man of wealth is likely to have a few odd children scattered about the country and no one thinks much about it.

The most pathetic thing in Venezuela, as in all countries founded by the conquistadores, is the narrow life forced by custom upon the women. Any respectable woman sees most of the world through the iron bars of the windows of her "*sala*," or living-room. A girl or woman who goes abroad without an escort is continually accosted by men. One American lady in Caracas said that the men frequently whispered things to her as she walked on the streets. One fellow who

TWO WOMEN POUNDING CORN FOR MEAL IN A MORTAR MADE BY HOLLOWING OUT THE END OF A LOG.

knew a little English hissed, "First prize!," in her ear as he passed.

Before the war Germany dominated Venezuela commercially. Numerous concessions were held by German firms and most of the capital which developed the country came from Germany. The well-known Germanic commercial methods were in vogue. Various schemes were practised in order to keep the prominent men of the country "in line." For example, General Gomez is said to have bought stock in a German company and to have received 1.5 per cent. on it each month for thirty years. There are many signs of German influence. The Venezuelan army wears typically Teutonic, spiked helmets, and "goose-steps." But as regards the recent war, the sentiment of the great mass of the people was with the allies.

Doubtless Venezuela will during the next generation or two lose much of the picturesqueness which makes it so attractive to-day. The free-handed hospitality of feudal times will have to give way to the suspicion and meanness attendant on commercial progress. A riper civilization will bring better sanitation, improved opportunities for every-day citizens, a broader outlook for women, better educational advantages, and other desirable changes. But the romance which always goes with grand estates dominated by great personalities must pass away. Feudalism will depart from Venezuela.

Ancient Indian idols, found on an island in Lake Valencia.

THE PROGRESS OF SCIENCE

THE ATLANTIC CITY MEETING OF THE AMERICAN MEDICAL ASSOCIATION

THE seventieth scientific assembly of the American Medical Association, held at Atlantic City during the second week of May, was notable as a celebration of the service of medicine to the nation in time of war. The attendance of members was about five thousand, nearly all of whom had taken an active part in national work, either as officers of the army and navy or in other directions. When the armistice was signed there were 35,000 medical officers in the army and 3,000 in the navy—more than one fourth of the entire profession of the country.

At the Atlantic City meeting there was a general opening session at which the president, Dr. Alexander Lambert, of New York City, gave the annual address and delegates from foreign nations were introduced. At a second general session national organizations, the activities of which have definite medical interest, were represented by speakers, each of whom gave a ten-minute address on the general subject of American medicine and surgery as it responded in service under war conditions. There were represented the Army, the Navy, the Public Health Service, the Red Cross, the Association of Military Surgeons, the American Health Association, the National Tuberculosis Association and the American College of Surgeons. The scientific papers and discussions of the meeting were presented before the fifteen sections into which the scientific assembly is divided.

The American Medical Association is by far the strongest existing organization of scientific and professional men. It is based on component state and county societies whose total membership is over eighty-two thousand. Its excellent weekly journal has a circulation of nearly the same size. The total number of physicians in the United States is less than 150,000, so that more than half of them are members of their organization. The National Educational Association has a membership of only about 10,000 from among some 500,000 teachers. Teachers are now forming unions in many cities, but the American Medical Association and the state and county medical societies have long accomplished the same objects, attested by the high standards of the profession and its great service to the nation.

MEDICINE AS A DETERMINING FACTOR IN WAR

THE part played by medicine in modern warfare was reviewed by Dr. Lambert in his presidential address before the American Medical Association. The subject was in part treated historically to show the great change which has resulted from advances in medicine, surgery and public health.

In earlier wars the decision has often depended more on the wastage of the armies by disease than on their fighting. In the Thirty Year War, which began in 1618, the battle casualties were only a few thousand, but typhus, smallpox, bubonic plague, dysentery and scurvy, with famine added to pestilence, reduced the population of Germany from sixteen to four million.

The Crimean War, 1854–1856, is said to show the highest loss from battle casualties among the Russians, and from disease among the French, of all wars of which we possess accurate records. The battle death rate among the British was 69 per thousand per year, among the

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FOREIGN DELEGATES TO THE MEETING OF THE AMERICAN MEDICAL ASSOCIATION

Among the delegates were: Sir St. Clair Thomson, Major General Sir Bertrand Dawson, Lt.-Col. Shirley Murphy, Sir William Arbuthnot Lane, Sir Arthur Newsholme, Dr. Ernest W. Hey Grove, Mrs. Eleanor Garton, and Col. W. T. Lister, England; General Melis, Col. A. Depage, Dr. P. Nolf, Prof. J. Duesberg, Capt. Van Der Velde, and Capt. René Sand, Belgium; Dr. Maurice Heitz-Boyer, and Dr. C. Mullon, France; Dr. Pedro Chutro, Buenos Aires; Dr. Juan Guiteras, Dr. Emilio Martinez, and Dr. Francisco M. Fernandez, Cuba; Dr. Israel Holmgren, and Dr. Sven Ingvar, Sweden; Dr. Peter F. Holst, Norway; Dr. John Constas, and Dr. Caroussos, Greece; Dr. Asajiro Kammimura, and Dr. Ryuzo Kodama, Japan.

French 70, and among the Russians 120. The disease death rate was 230 per thousand among the English, 341 among the French, and 263 among the Russians.

In the Franco-Prussian War of 1870, the Prussians reached the highest standard of protection against disease that any army had yet attained. The ratio of their battle casualties was 55 per thousand to a rate of death from disease of 25. The French, hampered by the quartermaster control of medical organization, in a demoralized, defeated army, suffered battle casualties of 68 per thousand and a rate of death from disease of 141. Among the French prisoners of war, smallpox broke out as a plague, about 14,000 cases occurring in Germany and about 25,000 in the interned army in Belgium. Smallpox followed as an epidemic in Germany, causing the death of 170,000 persons after the war.

Dr. Lambert reported that the death rate in our Civil War of killed and dying of wounds as 33 per thousand, the disease death rate as 65. In the Spanish War the death rate from battle was 5 and the death rate from disease 30.4 per thousand. The statistics of the American Expeditionary Forces, with an average strength of 975,716, reveal a rate of death from wounds in action of 31.2 per thousand and a death rate from disease of 11.2. Of those who died of disease, pneumonia claimed 9.1 per thousand.

In the Spanish-American War, 60.5 per cent. of all deaths were caused by typhoid, and in the present war 85 per cent. were caused by pneumonia. The pneumonia was mainly the result of the world-wide epidemic of influenza and the mortality of some American cities exceeded that of the camps. If the death-rate from pneumonia is subtracted the total death-rate from disease in the army at home and abroad is only 2.2 which is apparently less than the death rate of the men in civil life.

Dr. Lambert maintained that the importance of the Medical Department of the Army is such that it should be adequately represented on the General staff. In the concluding part of his address he drew the logical deduction from the medical lessons of the war, that this nation, through its present medical knowledge, has within its grasp the power to control communicable, and hence preventable, diseases, and that there must be established a nation-wide controlling organization for this purpose, a National Department of Health.

JOSEPH BARRELL

THE science of geology has had great losses during the past year or so in the deaths of Grove Karl Gilbert, George F. Becker, William Bullock Clark, Henry Shaler Williams, Samuel Wendell Williston, and now a man of the greatest promise, Joseph Barrell. All of them have been leaders in geology or paleontology, and Barrell stood as high as the highest.

Joseph Barrell was born at New Providence, N. J., December 15, 1869, and died in New Haven, after one week of illness, on May 4, 1919. He leaves a wife and four sons. He was descended from George Barrell, a Puritan who migrated from Suffolk, England, and settled at Boston in 1637, and was named after his great-grandfather, a patriot and wealthy shipowner of Boston.

Barrell was thoroughly trained in engineering at Lehigh University, and later in geology and zoology at Yale. He took three degrees in course at Lehigh, B.S., E.M. and MS., and in 1916 that university gave him her doctorate of science. On this occasion President Drinker said: "Joseph Barrell—Distinguished scientist, a recognized

For Forty Years Professor of Cryptogamic Botany in Harvard University, by whose death the United States suffers the loss of one of its most distinguished men of science.

JOSEPH BARRELL

Late Professor of Structural Geology in Yale University.

leader in the study and teaching of geology, known and honored for his research and writings in the science of the earth in which the earth's history has been written by a mighty hand—Lehigh is proud of the record of this alumnus, whose life work has been so modestly yet so ably done, and through whose work his alma mater has been highly honored."

In 1893, Barrell began teaching geology at Lehigh, leaving to take his Ph.D. at Yale in 1900. Then he returned to Lehigh until he was called to Yale in 1903. In 1908 he was made professor of structural geology. Recognition of his work by his fellow workers in science came last April in the form of election to membership in the National Academy of Sciences, the highest honor that can come to any American man of science. He was also a member of the Sigma Xi and of Phi Beta Kappa, a fellow and councillor of the Geological Society of America, and a fellow of the Paleontological Society. He had traveled widely in North America and in southern Europe, studying in the field the interrelations and deformations of the geologic deposits and their wear and tear by the forces of nature.

Professor Barrell loved to work at the more difficult problems of theoretic geology, such as the genesis and age of the earth, isostasy, and the strength of the earth's crust. His studies on the principles of sedimentation and their climatic significance have received much attention. In paleontology, he presented evidence to show that the fishes arose in the waters of the lands, and that lungs were developed, under the most trying conditions of semiarid climates, out of air-bladders of fishes. Similarly, that man "is peculiarly a child of the earth and is born of her vicissitudes."

In childhood Barrell was thinking of things scientific, and was even then more fond of books of learning and travel than of fiction and poetry. He was preeminently an observer and a student, and his recreation was scientific reading. Due to his training as an engineer, he always retained a liking for mechanics and mathematics, and through their aid loved to delve deeply into the broader problems of geology and biology. It was, in fact, these wider interests and the ability to work along so many lines that made him the deep and original thinker that he was. His colleagues at Yale will miss his stimulating originality. To them he was a second James D. Dana, and curiously both had a strikingly similar likeness.

C. S.

SCIENTIFIC ITEMS

We record with regret the death of Walter Gould Davis, for many years director of the Meteorological Bureau of Argentina; of Lawrence M. Lambe, of the paleontological staff of the Canadian Geological Survey, and of Edmund Weiss, director of the Vienna Observatory for thirty-two years.

The John Fritz Medal of the four national societies of civil, mining, mechanical and electrical engineering has been awarded to Major General George W. Goethals, for his achievement in the building of the Panama Canal.

Dr. W. W. Campbell, director of Lick Observatory of the University of California, has been named head of an American delegation of astronomers that will attend the international meeting in Brussels in July.

Dr. Vito Volterra, professor of mathematical physics in the University of Rome, will deliver a series of six lectures on the Hitchcock Foundation at the University of California in August or September.

Sir Arthur Newsholme, K.C.B., who is now in the United States has accepted for the academic year 1919-1920, the chair of hygiene in the new school of public health of the Johns Hopkins Medical School.